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POUR L'EXPLORATION DE LA MER
34B STRANDVEJ, HELLERUP – DANEMARK

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E. S. RUSSELL

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
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AOÛT 1935

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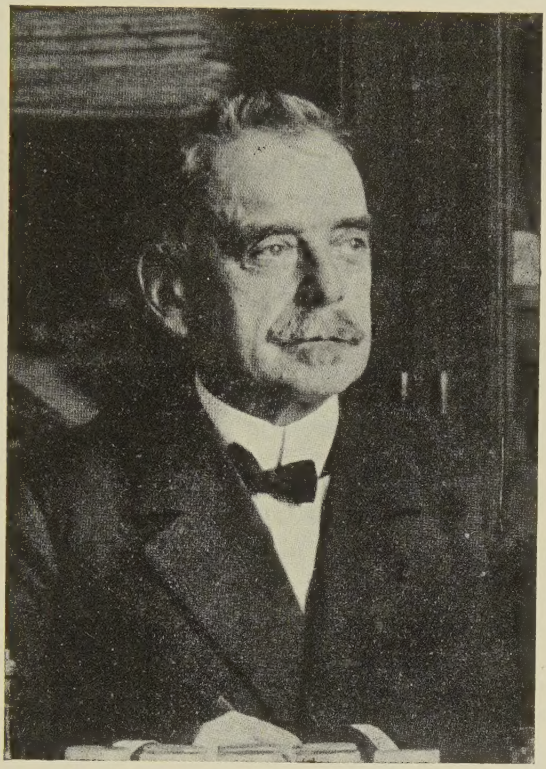

## Louis Joubin.
### (1861—1935).

DURING the night of the 23rd—24th April 1935, there died at Paris, after a long and painful illness, one of the most distinguished personalities of the scientific world, Professor Joubin.

The life of this scientist, known as he was to everyone in France and throughout the world, was entirely consecrated to marine biological research, and no one has earned in higher degree the gratitude of all those whose livelihood depends on the exploitation of the wealth of the sea.

Professor Joubin, born at Épinal on the 21st February 1861, had been brought up in the university world by his father, whose tutorial career took him successively to Épinal, Poitiers, and Angers, before he became headmaster of the Lycée Saint-Louis at Paris.

In 1885 M. Joubin took his degree as Doctor of Medicine; in 1888 he became Doctor of Science. He belonged to that remarkable generation of zoologists whose leader was Lacaze-Duthiers. Lacaze-Duthiers singled him out very speedily and, as soon as the Banyuls laboratory was founded, entrusted to him the post of demonstrator. Both on the Mediterranean coast at the Arago laboratory, and on the shores of the ocean at the Roscoff laboratory, Professor Joubin acquired familiarity in its smallest details with the marine fauna to which were to be devoted his remarkable labours.

He stayed for a few years at Rennes as lecturer, then he succeeded Dujardin as Professor of Zoology and became Dean of the Faculty of Science of that university. But in 1903 he was summoned to Paris as Professor at the National Museum of Natural History, and for more than thirty years he occupied the chair of malacology, where his predecessors had been Lamark, de Blainville, Lacaze-Duthiers, and Edmond Perrier.

Professor Joubin did not regard his professorial duties as limited to the preservation of the collections; his taste for research attracted him to studies of the widest scope, and very speedily he devoted himself to the researches which a science then almost in its infancy demanded — biological oceanography.

Prince Albert I of Monaco immediately found in him an invaluable collaborator, and this collaboration was to continue until the death of the navigator prince.

Professor Joubin made a cruise with him in the region of the Azores and when, in 1904, Albert I wished to introduce to the French public the marvels of marine fauna, it was M. Joubin to whom he turned and M. Joubin whom he asked to give lectures on this new subject at the Conservatoire des Arts et Métiers. Shortly after, in 1911, the foundation of the Institut Océanographique permitted a chair to be assigned to the great scientist, whence he was able to give regular instruction in biological oceanography.

When in 1919, immediately after the war, at the general desire of the French fishing industry, the Office des Pêches

Maritimes was constituted, Professor J o u b i n was called upon to assume the direction of this new department of state, and he proceeded to organize it in all details. He directed this difficult service until 1926, and then became Scientific Adviser to the Office des Pêches Maritimes.

Finally, in 1930, he was asked to fulfil the duties of Director of the Oceanographical Institute. As far back as 1921 the scientific world had given to Professor L o u i s J o u b i n the place due to him by making him a member of the Institut de France in place of Professor Y v e s D e l a g e.

His studies were principally concerned with the groups of invertebrate animals in which he specialized successively, and whose difficult systems and strange biology he studied. Thus his research on the brachiopods and the nemerteans and the deep water corals are familiar to all zoologists, but a very special place must be assigned to the masterly studies which he carried out on some strange molluscs — the cephalopods.

Professor J o u b i n studied the vast material of this class collected during the great oceanographical expeditions. The collections of the "Travailleur", the "Talisman", the "Hirondelle", the "Princess Alice", the "Belgica", the "Caudan", the "Siboga", the "Français", the "Pourquoi-Pas?", and the "Dana" constituted the subject of magnificent publications and by his labours Professor J o u b i n has profoundly modified our knowledge of these abyssal molluscs.

The scientists of every country appreciate, and will appreciate, at its true value the tremendous work done by Professor J o u b i n in his zoological researches, but those engaged in the fishing industry must above all think of him in connexion with the important role which he played from 1921—1926 as Director of the Office des Pêches Maritimes. Over a very long period M. J o u b i n took an interest in the question of the distribution of shellfish along the coast of France, and even before the war had published a remarkable series of charts showing the layings of these molluscs. He was admirably acquainted with our industry of oyster cultivation. Also we see him in 1921 and 1922 aiding by his great authority the enlightened oyster cultivators who wished to protect their industry from all criticism from the point of view of hygiene; it was in these circumstances that he became one of the principal promoters of the decree of the 31st July 1923, relating to the sanitary condition of shellfish, and the effect of the benefits conferred upon the industry of oyster cultivation is still felt after the lapse of a dozen years.

Other fishery questions were far from being strangers to him. With Professor R o u l e he had studied the food of the Atlantic tunny. He made for the use of trawlers a chart showing the distribution of the coral masses along the edge of the continental plateau. Finally it must not be forgotten that he was the first to conceive the idea of using aircraft to aid in the search for shoals of fish.

I have had the honour of collaborating in various matters with Professor J o u b i n over a period of almost thirty years. Our first labours in common go back to 1908; it was a chart showing the distribution of marine vegetables in the region of Roscoff. But this collaboration became still more intimate when he was Director of the Office des Pêches. We then undertook the task of the joint editing of the illustrated catalogue of edible marine animals and various other publications. In particular I shall never forget the great moral support which this eminent scientist gave to me when, in 1921, I ventured for the first time to enunciate my theory of Atlantic transgressions. In spite of many criticisms, Professor J o u b i n had the courage to present at the Académie des Sciences a note on this quite new subject, and to uphold my conceptions.

I must also record the great influence which Professor J o u b i n exercised in the International Councils engaged on marine questions. He was, together with the Prince of M o n a c o, one of the founders of the International Commission for the Scientific Exploration of the Mediterranean; he devoted to this commission constant and very assiduous service. For its benefit he drew up a catalogue of the fauna and flora of the Mediterranean, which was published in the shape of cards relating to each species.

Similarly in the International Council for the Exploration of the Sea, from the moment of France's adherence in 1920, he sat on the various committees as an expert, enjoying at once great authority and the affectionate esteem of his foreign colleagues.

Various foreign governments have recognized the great worth of Professor J o u b i n by conferring upon him the highest honours. He had in point of fact been decorated with the Grand Cross of Spanish Naval Merit, and was Commander of the Orders of the Dannebrog, of St. Maurice and St. Lazarus, of the Star of Roumania, and of Leopold of Belgium. Finally, in 1921 Professor J o u b i n was made a Commander of the Legion of Honour.

An experienced and disinterested scientist, an enlightened administrator, a faithful and honourable friend, Professor J o u b i n combined in his personality the qualities which distinguish the greatest of mankind. His memory will be piously preserved in the Office des Pêches Maritimes of which he was the first Director and the devoted organizer.

*Ed. Le Danois.*

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# A "Vertical Log" Current-Meter.

By

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"Vertical Log" is the convenient name which, for brevity and to avoid confusion, it is proposed to give to a simple, cheap, and very sturdy current-measuring apparatus recently tested.

## The Purpose of the Instrument.

The instrument to be described was designed in the hope that, by use of it, action could be taken along the lines of two resolutions of a committee of the International Council for the Exploration of the Sea. At the 1930 meeting of that body, the Southern North Sea Committee resolved that the following suggestion be forwarded to the appropriate quarter:—

> "That the continuous current investigations as carried out on the Varne Lightvessel be extended so as to embrace lightvessels on both sides of the Southern Bight."

Two years later the resolution of 1930 was repeated in effect, though in different terms.

In the writer's opinion useful progress along the lines indicated could be expected only if some cheap and robust apparatus incorporating no self-recording device for direction became available. The use of an instrument employing a compass needle would seriously limit the possibilities of work at shallow depths from steel vessels.

With the above considerations in view, the apparatus to be described below was designed. At all stages the fact was borne in mind, that to perform the work required of it, the instrument would have to be able to work continuously under very exacting conditions indeed. As will be realized later, its utility need not be restricted to the purposes of fishery research by any means.

Many readers of this Journal will be familar with the nature and performance of most existing types of current-meter. If reference be made to a recent book by T h o r a d e (**1**)[1]), where good descriptions of the various instruments are to be found, it will be agreed (so we think) that, if it be desired to carry out observations which will provide an unbroken series of records concerning the water-flow past, say, a lightship moored at an exposed station, the choice of instrument is by no means wide. Any current-meter which it might be proposed to use for the purpose would be quite useless unless it could survive such treatment as it would receive if submitted to the rigours of a month of winter storms. Submission to such treatment would be a suitable preliminary test of fitness as enabling one to judge the likelihood of an instrument being able to remain in operation for something like a whole year without disaster. It will probably be agreed that no fine precision instrument of the propeller type would be able to do so. Even in the very unlikely event of such an instrument suffering no visible major damage, the "sand-blasting" to which it would be subjected could hardly fail to wreak serious havoc to the propeller and mechanism — at least at such an observing post as a lightvessel off the continental coast.

We may recall S c h u m a c h e r's statement (**2**, page 20): "Ein schwer vermeidbarer Nachteil des überaus empfindlichen Instruments besteht darin, dass bei Beobachtungen in grossen Tiefen beim Fieren und Hieven trotz aller Vorsicht häufig die Propellerblätter verbogen werden," and may readily picture the damage which would result if one of those instruments were hung out from an exposed lightvessel for even quite a few days during severe weather. The value to the fishery researcher (and perhaps to others) of such current data relating to open-sea positions as have come from the use of fine precision current-meters in the North Sea, would be much greater than it is, if one knew how justifiable it is to generalize from them. It is, however, hard to see how one can expect ever to know this, since such data as *are* available relate only to very brief periods, and the instruments in question can never be used for long enough to produce continuous data for even one whole year. Even if they could survive rough usage for a considerable time, their factors would have to be called in question as the propeller and mechanism became eroded through "sand-blasting". Moreover, judging by the amount of "weed" etc. which is to be seen drifting by on many occasions, one would have to expect observations to be frequently spoilt because the propellers have far too little strength to work themselves free from such material. Also, one could not hope to remain free from trouble for long in respect of real damage resulting from collisions with pieces of waterlogged wood or jelly-fish.

In view of these considerations, the writer finds it difficult to see how the records standing to the credit of fine precision current-meters

[1]) See "List of References" at the end of this paper.

are to be rightly appraised in point of real utility in fishery research connexions.

It is worth emphasizing that there is no lack of opportunity for at least attempting all-weather continuous current-measurements, and attempted they should be unless one is to remain content with the very one-sided picture provided by fair-weather data. Lightships are invaluable observation posts and from them observations can be made all the year round. Also, given the special anchoring gear and experience at the disposal of some ships, a certain amount of continuous observing could be done at positions in the North Sea under circumstances which would be beyond the resources of ordinary fishery research vessels. Rear-Admiral S p i e s s has recently given a full and clear account of the technique of deep-sea anchoring for current-measurements (**3**). In that article he has much to say concerning the problems inherent in current-measuring from anchored vessels, and cites the experiences and opinions of many well-known investigators.

If, as we surely must admit, it is often during bad weather and in seasons when continuous observations on currents are least easy to keep in train, that we should most like to know how various organisms in the sea are being affected, then serious efforts to carry out more continuous current-measurements must be made.

It is well to state here that the prime desideratum, viz. continuity, accounts for our paying no attention to the practice of current-measuring from a vessel not at anchor. Admiral N a r e s has described a method of doing that (**4**), but it would seem impracticable to keep a vessel under steam for long enough periods to produce data of the kind here in question.

About ten years ago it seemed to the writer that there was a need for some current-measuring instrument which would permit observations to be carried out for long periods under not merely the worst conditions in which it is possible to anchor, but under the worst conditions which ever occur off the coasts of the English Channel and the North Sea, and in 1926 (**5**) he described an instrument designed to do so. An up-to-date account of the instrument in question is given in *Fisheries Notice* No. 17, and a report has recently appeared (**6**) presenting about eight years' records obtained from the continuous use of it at the Varne lightvessel in Dover Straits. Certain of the results obtained in recent years at the Varne lightvessel are not, however, easy to understand fully. To ascertain the meaning of a long-enduring set on to the Kent coast — in terms of contemporaneous current-conditions in the southern North Sea — we require continuous current-data from coastal light-vessels, and this could be forthcoming if such an instrument as that to be described were put into use.

With the Drift Indicator, only about a quarter of an hour has usually been lost each three days; with the instrument to be described below no time at all need be lost, as it need not stop working even momentarily for the records to be taken.

Drift Indicators (which have now been in use for nearly ten years)

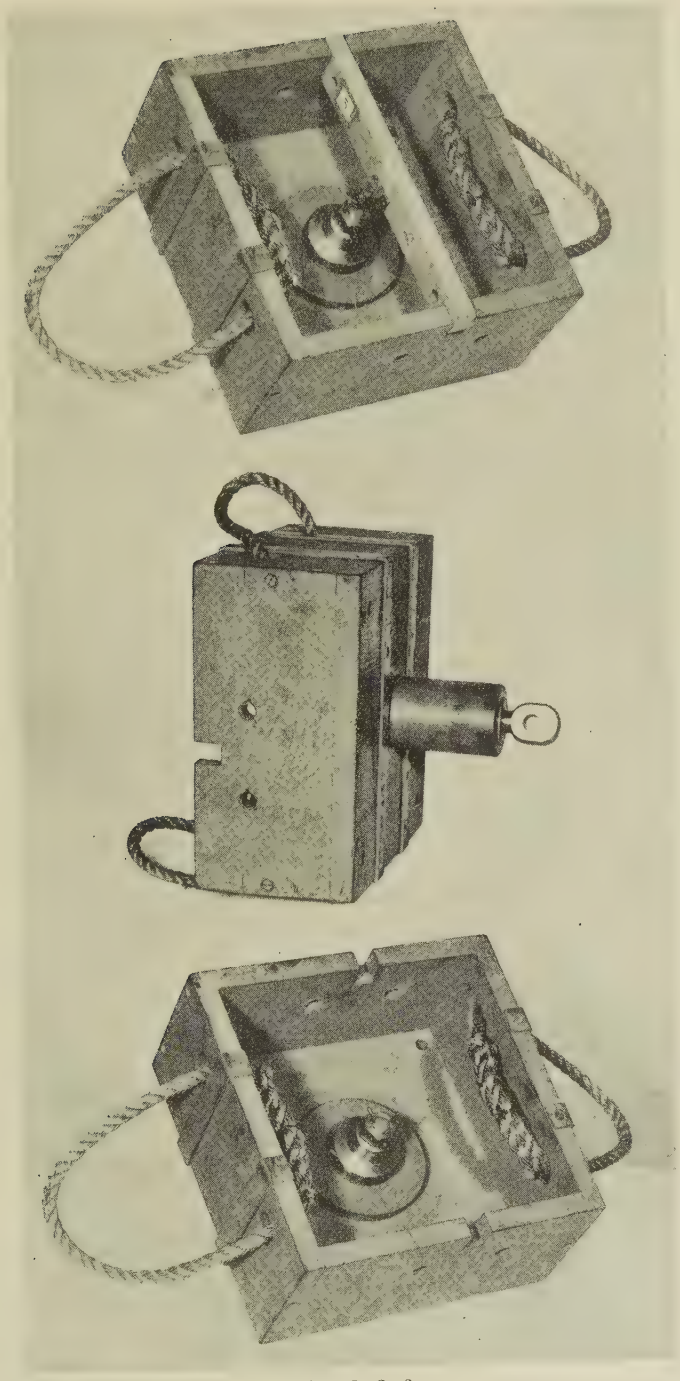
are not, however, cheap, and although one of them has never been lost from the Varne lightvessel, it cannot be pretended that an observer is completely free from all anxiety, in view of their cost.

With the Drift Indicator, observations of the kind desired cannot be made at shallow depths except from wooden vessels. This is a serious disadvantage — for many reasons which are obvious enough.

Although continuous observations upon the water-flow past many steel lightvessels off the continental coasts are very much to be desired for the elucidation of certain important fishery research problems, it was not for that reason alone that the instrument to be described below was devised. Another reason resided in the wish to test certain opinions recently advanced by T a i t (**7**) concerning the currents in the North Sea — particularly in the middle and northern parts of it. If T a i t is right in his idea of stream currents, it may be the case that the dispersal of important organisms is usually less diffuse than might be supposed — to mention only one point of interest. T a i t's opinions concern the uppermost water layer, and to test them adequately, many measurements of surface currents would have to be made from steel research-ships at many places. It would be an achievement of first-rate interest if one could discover even one lane of water moving at, say, about ten miles a day between bands of water moving at a substantially less speed, and could later proceed to delimit the various swirls to which so much interest attaches. In this connexion, co-operation from such a vessel as the "Meteor", with her experience of anchoring in deep waters, would be invaluable when the search for the eastern periphery of T a i t's Great Northern North Sea Eddy was in train.

An ambitious programme of current-measuring is planned for the area occupied by the South-West Dogger Bank Swirl in conjunction with salinity distribution investigations and experiments with drift-bottles which remain afloat only for a time.

Hitherto we have been restricted to the observation of currents at a magnetically safe depth in this interesting area. Considerable interest would attach to a repetition of an experiment made eight years ago (**8**) dealing with the interpretation of salinity distribution charts — if it became possible to carry out shallow current observations in addition to deep ones such as were then made. It might be that we should be able to obtain a completely acceptable velocity reference datum for hydrodynamic calculations. The instrument described below does enable continuous data upon water-flow past an anchored steel ship at levels near the surface to be obtained — but at a price. It is, like another simple instrument (J a c o b s e n's Libelle Meter), not automatic in point of direction-recording. Therein lies its cheapness and an admission that it is not a substitute for the more expensive Drift Indicator. The latter needs no attention at all for days on end, and, where deep observations are acceptable, it is intended to go on using it as hitherto. The new instrument needs fleeting attention (often no more than a glance, however) every now and again. Sometimes as experience will show,



Figs. 1, 2, 3.

it will be possible to leave it unlooked-at for four and more hours on end; at other times it will call for a glance every quarter-hour or so for a time.

## Description of the Instrument.

The instrument comprises two main parts. The part which is submerged when in use consists of a system of very strong iron cups below which a heavy weight is suspended. This heavy weight is a cylindrical steel tube weighing 58 lb. (26.3 kg.). It is about 6 feet in length (1.8 m.) and somewhat more than 6 inches (15.2 cm.) in circumference. An eye at one end of it is joined to an eye at the bottom of the cup system by a short length of 2½-inch rope. The cup system (see Fig. 5) is a very sturdy and heavy affair. It was made so in order that no trouble could result from jelly-fish, floating weed, or even pieces of waterlogged timber. The cup arms are borne on a steel rod of hexagonal cross-section and are welded on to it. Each of the six faces of this rod is ½ inch (12.7 mm.) wide, and the rod is about 54 inches (137 cm.) long. The cup arms are made from steel rod $^5/_8$ inch (15.9 mm.) square in cross-section, and are of such length that a cup centre is about 14½ inches (36.8 cm.) from the vertical rod. The arms are not entirely straight but have a slight bend in them near where they are attached to the rod. The purpose of this is to approach the arrangement in the Drift Indicator where the cup fronts are in line with the axis around which they turn. The cups are of cast iron and are 6 inches (15.2 cm.) in diameter. They are secured to the arms by very strong nuts. Viewed from above as the rod hangs, the cup arms are spaced round the circle at angular intervals of 60°. Vertically, they are disposed along the rod at equal intervals.

The entire cup system weighs 42 lb. (19 kg.). At the top of the hexagonal rod is an eye into which is secured one end of a length of 2½" rope about a fathom longer than the distance the ship's rail is above water level. This rope can be made of greater length if observations are most frequently to be made at a depth exceeding a fathom. In that case the rope can very conveniently be sheep-shanked or otherwise dealt with to shorten it for occasional shallower observations — so long, of course, as nothing but single rope is left below water. The upper end of the rope (we are describing the apparatus as rigged for use) is secured to the eye at the end of the steel spindle shown in the illustration (see Fig. 2). This is the attachment to the registering part of the instrument which may now be described. A very strong box, made of hardwood and strengthened by iron bands, houses the simple recording arrangement. This box is about a foot (30.5 cm.) square and little over half that depth — and has no lid. In the centre of the bottom of it is borne a vertical steel spindle mounted in a ball-bearing collar; at the bottom of this spindle (below the box) is the eye to which the rope is secured. Downwards-pull on the spindle is taken on a steel ball race, and the whole affair is of

Fig. 4.

great strength. Provision is made for lubrication of the spindle. On the top of the spindle a large nut is secured, and mounted vertically in this is a steel pin about an inch long which describes a circular path as the spindle is rotated. The box is provided with two rope beckets secured in the sides which face towards and away from the ship when rigged for use. These beckets are slipped over a circular wooden pole which projects horizontally from the ship's rail a few feet and which is guyed strongly to prevent any movement. This pole and the beckets can, with advantage, be smeared with grease. In the fore and after sides of the box a slot is cut as shown in the illustration. Into these slots one of a number of hardwood slats can be shipped. On each of these slats a revolution counter is mounted as shown, and when a slat is in position and the instrument working, the handle of the counter is carried round by the vertical steel pin already mentioned. These slats are very easy to place in position or remove, and each one is labelled for a specific sector of the compass. In the instrument tested, each revolution counter was labelled for one octant, thus:—

No. 1 relates to the four points NNW — NNE.
No. 2 relates to the four points NNE — ENE — and so on round the compass to No. 8.

Each sector straddles one of the eight main directions. It is possible that eight counters will prove to be the best number to have, and that 45° sectors will prove to be as small as can conveniently be dealt with. Experience will show. In the illustration (Fig. 4), the counter slats labelled A, B, C, and D are emergency substitutes — to be re-labelled as necessary to take the places of any which might be damaged or carelessly dropped overboard. It is not expected that in normal use ordinary wear will give any trouble for long periods; the counters are turned fairly slowly and are under no strain.

It should be mentioned here that the counters throw one number for each revolution of the cup system, and that in future instruments they will read up to 99999. It is well to mention also that a preventer rope is slipped through the inner becket of the box and made secure on deck when the apparatus is working. As to the best number of counters further remarks will be made later.

When the apparatus is working, the counter in operation records the actual number of revolutions made by the cups, there being no gearing up or down. This makes for simplicity and cheapness and, as trial has shown, is convenient.

As we said above, direction recording is not automatic. When we first had the idea to design some simple current-measuring apparatus akin in a way to a patent log, we attempted to design something which should incorporate a self-registering device for direction. This would not have been at all impossible had we decided upon an instrument using a type of rotator drifted astern. The difficulties of devising anything reliable in the way of a rotator were too great, however, — as can easily be imagined, for one had to cater for slack water. Any

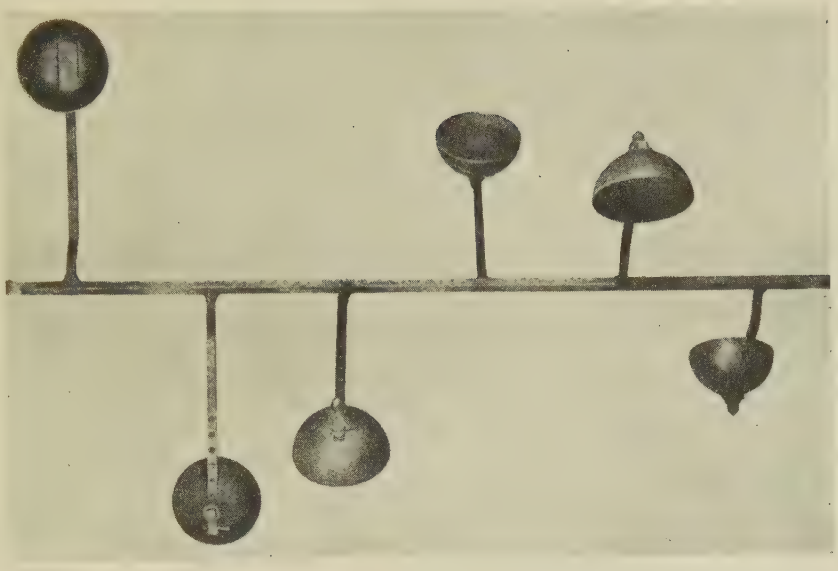


Fig. 5.

Fig. 6.

rotator which was heavy enough to remain properly submerged when a good stream was running, would sink when the stream was dead, and any floating rotator would not submerge properly.

Various ways out of the difficulty suggested themselves but were not proceeded with. One of the chief reasons for this was the fear (a well-grounded one) that, used from a lightship, there would be a real danger of having the apparatus (even the inboard part) torn away by passing craft. This would be especially likely during foggy weather. Again, one wanted, if possible, to have an instrument which could be rigged in the waist of the ship. It was finally decided that prospective cheapness and sturdiness would more than make up for the omission of any self-recording device for direction. The direction is taken from a log streamed astern. Clearly, if the instrument is to be used in the waist of the ship, one could, if desired, take the direction from the showings of a bubble in a level after the manner of Jacobsen's meter, but one wants to work in bad weather, and the bubble movements in a Jacobsen meter dial are then very lively — as anyone who has had much experience with that instrument will know.

There was one paramount consideration in view all the time and that was one which cannot be too much emphasized — the desirability of arranging to get records which should call for the very minimum of office work ashore later. The writer aimed to get records as similar as possible to those simple ones coming from the Drift Indicator so that one could easily keep up to date with the large numbers of records which would come in. This important desideratum accounts for the arrangement decided upon and which has been used in the trials.

The log-ship drifted astern for direction-viewing purposes is the type which has been used for log-ship current-measurements by the writer for over eight years. It is figured in the illustration (Fig. 6). The upright is a 33-inch (about 84 cm.) long piece of wood which is 2 inches (5 cm.) square in section. Each of the six wooden cross slats is 24 inches (about 61 cm.) long, 3¼ inches (82.5 mm.) wide, and ½ inch (12.7 mm.) thick. Each slat is firmly screwed on to the upright at right angles — the attachment being made at the middle of the slat. Alternate slats are at right angles to each other. This object floats in the water with the top just awash — the length of old chain attached having been chosen to arrange for that. The log-ships described have been long soaked in creosote or painted (when the wood was undressed) with cellulose paint — to obviate waterlogging. One of them is streamed out astern on a fairly long length of sash-cord, since on a long lead one gets the direction better when the ship's stern is swinging about at all.

It is intended later to try using a large heavy galvanized bucket hung from a spherical trawl-float and streamed on a one-inch line. This will be done to get a stronger pull to suit a convenient arrangement already used and which will be described. If one were current-measuring at depth, then the bucket or other object could be suitably hung low enough down to reach the level concerned. An observer could suit himself in respect of the log-ship used, however.

It is clear from what has been said that one could proceed using only one counter. This could be read at desired intervals of time and the direction of the stream noted as precisely as possible on each occasion. For some purposes this would be all that would be necessary, and such a practice would produce results of the type needed if one wanted to know the amount and direction of flow during specified hours related to the high-water times of a standard part. In the case of a research ship, the amount of attention needed to observe in that manner would not matter much, since if anchored for the express purpose of current-measuring, the necessary observer would certainly be available. Obviously the instrument in that (as in any other) form could not be used from an unattended buoy, but, desirable as unwatched working from a buoy is, the fact remains that much the most current-measuring has been done from anchored ships and will almost certainly continue so to be done. Hence the need for an observer is not as serious a disadvantage as might on first thought be supposed. In the case of a lightship, however, one must cut down the work to be done by an observer to the very minimum. The need for even a small amount of clerical work every quarter-hour or so would never do. Moreover, above all things, we want very simple records if we are to get the continuous flow data we aim at for fishery research problems — since troublesome office work on the records must be avoided. For this reason, a number of counters are made use of, and the direction recording is performed in a way which calls for a mere three minute's clerical work once a day — or even less frequently, as desired.

We will describe the arrangement we have employed as it could be modified for use on lightships which have the convenience of a more or less unobstructed after-deck.

Arrange to set up vertically, at a position as conveniently near the ship's compass as possible, a strong thin mast with a stop on it at about waist level. Let the top of the mast be somewhat higher than surrounding obstructions — well above rail level at least. On one face of a flat circular disc of clean hardwood about a foot in diameter, stick a photo-copy of a good compass card. Let there remain an annulus about an inch wide uncovered by the compass card. Divide the rim so left blank into compartments in a manner which will be obvious from what has been said above, and paint in the numbers 1, 2, 3, and so on to suit. Apply several coats of varnish to the wooden compass card so prepared, and provide it with a central hole so that it can be slipped down the mast to rest upon the stop. From the fore-side of the stop let a stiff wire pointing to the ship's head project, and bend it upwards and backwards so that its end points downwards on to the rim of the wooden compas card — which latter can of course be turned round with the mast as axis. Let the inboard end of the log-line be attached to the top of the mast and arrange to let the direction of the line reproduce itself lower down — just over the dumb compass. This can be done in an easy manner hy hanging a light rod underneath the log-line by means of several vertical strings.

The forward end of the rod can conveniently carry a light ring which is round the mast. It is easy to arrange that this rod is only an inch or so above the wooden compass. In this way one gets a convenient arrangement which renders it unnecessary to peer over the side at night time or in fog, and matters become very simple if there is a good pull on the line. This can, as suggested above, be easily arranged for.

The technique is now simple, recording reduced to the minimum, and all set for the simple type of record desired. The observer records the initial readings of all his eight counters and does no more recording until the next day. Having next observed the ship's head and set the dumb compass accordingly, he puts into registration the appropriate counter. He knows which this is by noting over which sector the log-line leads. His job thereafter is to give an occasional glance at the dumb compass to see whether it needs turning at all to keep it set to the ship's course, and to learn when it becomes necessary to substitute another counter in the recording box. Quite often on such a ship as the Varne it would be unnecessary to do anything at all for hours on end since, when the ship was properly riding the ebb or flood, the line would stay in one sector for a long time. Clearly, with suitable marks visible — such as the watch buoy of a lightvessel or a prominent shore-feature or other object whose bearing was well known, — the routine could be much simplified. The dumb compass could be kept set to such a mark — a practice which would be easy even in the dark on clear nights if, say, a tack were put in the rim of the dumb compass at the proper place. If the circumstances were such that it was convenient to set to a distant object in this way, then for night use the sectors could be picked out with luminous paint and working would be further simplified.

If long-maintained observations from an anchored research vessel were contemplated, it would be very convenient to anchor a dhan-buoy to the true north of the position at which it was intended to work. If the buoy were lighted and were far enough away to ensure that the swinging of the ship on her cable introduced no direction errors, then given the absence of fog, all would be easy and there would be no need to watch the ship's course — as would have to be done in thick weather or in the absence of a buoy mark.

After the observer had carried on as explained for the time appointed (24 hours 50 minutes or any other chosen period) he would record the readings of all eight counters. The record he would send in would be a very simple one indeed. With an apparatus using eight counters he would have record sheets which would serve for a week or more. His final readings of one observation would be the initial ones of the next — since the apparatus does not need to be stopped for the records to be taken. Different workers would have different ideas as to the type of record sheet desirable, but the data would arrive in a form permitting very easy treatment. Having simply converted from revolutions to miles for each counter (and this could be done in a very few minutes on reference to a prepared table) one

would know how many miles of water had flowed towards the different directions. It would be a very simple matter to make the further step and work out a residual — by means of a simple schedule such as is used in treating the large numbers of Drift Indicator records received at the Lowestoft laboratory. Thus one would very easily get the type of data suitable for application to fishery research problems.

As stated earlier, some other number than eight counters could be used if desired — though eight would be very suitable for routine work on a lightship. Twelve might be suitable for use on a research vessel, but it may be recalled that, in the course of the Four-Nation Cattegat researches of August 1931, stream directions observed from the drift of a Finnish "Stromkreuz" were considered reliable only to about 20° (**9**). Before presenting sample records taken with the new "Vertical Log" current-meter, we may comment on a few other features of it.

## Various Additional Features and Uses of the Instrument.

It is to be realized that in the case of certain places of observation, the work would become simplified exceedingly. Used hung from a bridge over a river, sometimes only one counter would be necessary and no attention needed for as much as a week unless desired. Used in harbours and estuaries, sometimes only two counters would be necessary, and experience would dictate approximately at what times the instrument would have to be visited to change the counter — or to read it if the same one were to be left in for the new direction of stream. In such places as harbours and rivers with much shipping, the instrument's ability to withstand, without damage, collision with a variety of floating objects would be a very useful quality.

It is a feature of the instrument that it could not stop working without the fact being soon noticed — as the counters are visible. As regards the amount of attention the instrument needs, it is to be recalled that ordinary log-ship observations are a routine matter on German, Swedish and Finnish lightvessels, and that on German North Sea lightships they are carried out 6 times a day.

The wear and tear which the new instrument should suffer can hardly turn out to be other than negligible, and if a few spares (not bulky to stow) were supplied, there should be no cause for any stoppage of work for well over a year — perhaps for much longer. There is nothing to go wrong but what can easily be set right on shipboard by seamen. Then again, one has no anxiety through fear of loss if the instrument is properly rigged and the ropes renewed from time to time. If desired, one can turn all the counters to zero for new observations — by holding them in an obvious manner against the spindle of a high-speed emery-wheel such as is to be found in the engine-room of most vessels. In any future instruments, the cups could be heavily galvanized and a master counter could be fitted if desired to total up the revolutions of the various counters used.

The instrument could conveniently be used from piers or attended

beacon lights and in such cases a dumb compass could be painted on a board fastened to the ground. Used from piers even much extra weight would not matter, and the instrument could therefore be better corrected against any effects of canting than when used on shipboard. Observations of long duration very close in shore are scanty indeed and would be very useful. Apropos the question of canting, it will have been realized by the reader that the very simple method of suspension employed (rope beckets on a greased round pole) effectively provides that the spindle always aligns itself with the transmitting rope when the latter is not vertical.

The main feature of the instrument is of course its employment of rope transmission from cups to recorder. This feature, in conjunction with the great strength of the cups, is confidently expected to endow it with all-weather qualities not otherwise attainable. The use of rope is expected to reduce any over-registration during lively weather to a minimum — particularly as six cups spaced round the circle are employed. It is expected that any undesirable effects on registration due to lifting and diving on the part of the ship will better counteract each other than in the case of an instrument like the Drift Indicator, which will turn bodily as these and other opposite motions of the ship succeed each other. Clearly, with some instruments, if the ship rode so many fathoms towards her anchor and then an equal distance from it, the revolutions involved would be additive. With the Vertical Log perhaps only half (or less) as many undesired revolutions would be recorded, and since it turns much more slowly than other instruments, such errors would probably tend to be kept to small proportions. It is necessary to pay serious attention to the matter just considered — the question of faulty registration during very bad weather — and we propose to take as early an opportunity as possible to investigate it. It is intended to do continuous runs with a deep-riding log-ship over several hours at least from a lightship during heavy weather, and to note whether the instrument's showings tally with the information derived from the log-ship runs.

## Calibration Tests and Sample Records.

The first (and at the time of writing only existing) Vertical Log was tried out and calibrated from the research vessel "George Bligh" in April 1935. The calibrating was done in Corton Roads on 12th, 17th and 18th April. The method was to note the number of revolutions made during the time taken for a measured length of line to be pulled out by the log-ship figured in the illustration and described above. The line used was a properly seasoned one, and had been carefully measured several times by walking it (under the strain experienced in actual use) along a surveyor's chain stretched along the ship's deck. Three observers co-operated in the tests, and a good stop-watch and stop-clock were used. Something approaching fifty runs were made in all. The speed of stream varied from just under ⅓ to

just above 2⅓ knots. It was not possible to work in any speed of stream outside this range on the cruise concerned. It suffices here to say that, over the range of speed experienced, the instrument registered with very satisfactory uniformity. The accepted factor was:—

270 revolutions = 1 sea-mile.

There seemed a tendency for the instrument to make one or a part of one revolution more per log-ship run at the highest speed met with, but to get proper evidence of this one ought to run a much longer line away so that it would not be necessary to estimate half-revolutions as we had to do using the line available. If it does turn out to be the case that the instrument over-registers at high speeds as compared with low to a degree demanding correction, we anticipate no great difficulty. On this point, however, we may remark that in the course of log-ships observations at the Varne lightvessel stretching over 12 weeks in each of two winters, the highest stream rate measured was 2.6 knots (134 cm./sec.). We propose to work the instrument in the River Humber in a 5-knot stream, and, if the registration falls off seriously, we shall try various devices to correct it. We have simple ones in mind of a type (as is necessary) which would add nothing material to the cost of the apparatus.

It is well to remark that the cups were seen to be rotating when it was difficult to distinguish any movement on the part of match sticks thrown over the side of the ship.

Testing registration at low speeds is not simple if one prefers (as we do) to calibrate under the conditions of actual use. On the occasions in question, very low speeds were met with only when the ship was on the point of swinging, and then there came a time when the log-ship would not float away from the vessel although the cups were rotating. This touches on an interesting question, What is it that a current-meter of the Ekman type records under such circumstances? Only if the ship were anchored astern as well would the true set at what would otherwise be swinging time be recorded. As it is, from a ship riding to a bow anchor only, one must get a record of a resultant motion compounding several effects easy to appreciate, and there may be no record of there ever having been a set from the precise direction it *was* from at swinging time.

With an apparatus demanding the visual observation of direction, one is perhaps, despite the extra trouble, in somewhat better case, though usually the water movements effected at swinging time will be of little importance. In this connexion one may remark that it would be interesting to know what amount of spread of the balls dropped by an Ekman-type meter is referable to swinging of the meter as the ship lifts and dives in rough weather. We can hardly expect to learn this as the Drift Indicator is the only one (so it is thought) which has been used in really heavy weather, and that remains down for too long for the effect to be discoverable. The point here is that, for all we know, and despite the alleged difficulties of estimating the direction of a

log-ship reliably, we may get just as good direction-recording with the Vertical Log apparatus as with the Drift Indicator — particularly at times of heavy weather.

Three further remarks only are necessary here. If when working the Vertical Log, the log-line leads out over the dividing line between two direction sectors, it is well to leave in registration the counter relating to the sector from which the line shows signs of being about to pass; some such convention as this is desirable. If it happens to be raining when the apparatus is in use, it is convenient to drape a piece of water-proofed material over the recording box; up to the present we have preferred not to fit the box with a lid. An observer can easily know which counter is in use by noting which is absent from the box or rack in which the whole set is kept.

Clearly, although the counters will usually be read each day or half-day, so that in the event of any mishap the minimum of time will be wasted, one can choose for what periods of time one works up the records. If suitable, one can neglect readings relating to shorter periods than a week, or can choose 3-day periods for comparison with Drift Indicator records.

## The Price of the Instrument.

The makers (Messrs. Elliott and Garrood, Beccles, Suffolk, England) expect that, when a number of these instruments has been made, the price (allowing for ten five-figure counters) will be £ 12 within a very little. No provision is made in that estimate for any direction-indicating accessories since they can best be home-made for a few shillings to suit the tastes of the person who intends using the instrument.

## Sample Results.

Below are given the results from the first three observations made with the Vertical Log. In each case the observation was made from the research vessel "George Bligh", and (with a reservation noted below) all three observations lasted for 24 hours 50 minutes. To achieve compactness in the table, symbols are employed; their meanings are:—

"*A*" relates to an observation made in Bridlington Bay abreast of the town and with Flamborough light bearing about ENE. magnetic. The date of commencement was 14th April 1935 and the wind during most of the time was of strength 3 Beaufort and from a SE.'ly point. An idea of the state of the tides can be conveyed by comparison with the H. W. F. and C. hour for Dover — which is 11.19. On the occasion in question Dover H. W. was at 9.11.

"*B*" relates to an observation made one mile NNE. of the Owers lightvessel (which is about 10 miles south of Bognor Regis) and commenced on 27th April 1935. The wind was NE.'ly and of strength 2—3 Beaufort. Dover H. W. on that occasion was at 5.22. Unfortunately the observation was inadvertently finished ¾-hour too soon.

"*C*" relates to an observation in Corton Roads commenced on 1st May 1935. The wind was SE.'ly and of strength 2—3, and the time of Dover H. W. was 9.40.

In the table below, the small letter "a" heads columns giving the data (water movement in miles) for the first half-days; under "b" are entered those for the second half-days, and under "a + b" are given the data for the entire periods of 24 hours 50 minutes.

| Directions (magnetic) towards which the Stream ran. | A | | | B | | | C | | |
|---|---|---|---|---|---|---|---|---|---|
| | a | b | a+b | a | b[1]) | a+b[1]) | a | b | a+b |
| Between NNW. & NNE. | 0.3 | 0.6 | 0.9 | Nil | Nil | Nil | 7.6 | 6.8 | 14.4 |
| „ NNE. & ENE. | 3.4 | 3.9 | 7.3 | Nil | Nil | Nil | Nil | 0.2 | 0.2 |
| „ ENE. & ESE | Nil | Nil | Nil | 4.2 | 4.6 | 8.7 | Nil | Nil | Nil |
| „ ESE. & SSE. | Nil | Nil | Nil | 0.9 | 1.2 | 2.2 | Nil | Nil | Nil |
| „ SSE. & SSW. | Nil | Nil | Nil | 0.2 | Nil | 0.2 | 9.5 | 10.6 | 20.1 |
| „ SSW. & WSW. | Nil | 0.1 | 0.1 | 1.8 | 1.1 | 2.9 | 0.2 | 0.3 | 0.4 |
| „ WSW. & WNW. | 1.1 | 0.6 | 1.7 | 5.1 | 5.0 | 10.2 | Nil | Nil | Nil |
| „ WNW. & NNW. | 0.7 | 0.8 | 1.5 | Nil | Nil | Nil | Nil | Nil | Nil |
| All Directions | | | 11.5 | | | 24.2 | | | 35.1 |

[1]) One or more of the entries in these two columns must be somewhat less than what it or they should have been — for the reason stated in the text.

If we refer the water movements entirely to the middle directions (N., NE., E. SE., and so on) and compound them on that basis, we get the following resultants:—

Aa — 3.3 miles towards N. 2° E. true
Ab — 4.2 — — N. 9° E. —
Aa + b 7.4 — — N. 6° E. —

Ba — 2.7 — — S. 25° W. —
Bb — 1.7 — — due S. —
Ba + b 4.3 — — S. 15° W. —

*(Reservation:*— See the above note which applies to these last two results).

Ca — 2.1 miles towards S. 8° E. true
Cb — 3.8 — — S. 10° E. —
Ca + b 5.9 — — S. 10° E. —

*Note added at Proof Stage.*

Four days have recently been occupied carrying out a thorough test of the instrument from the research vessel "George Bligh". The ship was anchored in Hawke Roads in the Humber estuary, and the effects of using six different substitutes for the cylindrical steel weight below the cups were investigated under all strengths of stream experienced. With one arrangement it was found possible to obtain extremely

satisfactory indications over a range of speeds from below 1 to slightly over 3½ knots. No greater speed than the latter was observed.

The tendency to over-register at the greater speeds was finally corrected by using in place of the steel rod weight, a length of chain (steering-gear chain) weighing 50 lb. to the free end of which was shackled a small 3-bladed propeller weighing about 10 lb. The type of propeller chosen was such as would oppose the cups when the chain was carried far enough out of the vertical for it (the propeller) to be urged to rotate and so act as a brake.

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# The Dissociation Constant of Cresol Red in Sea Water.

By

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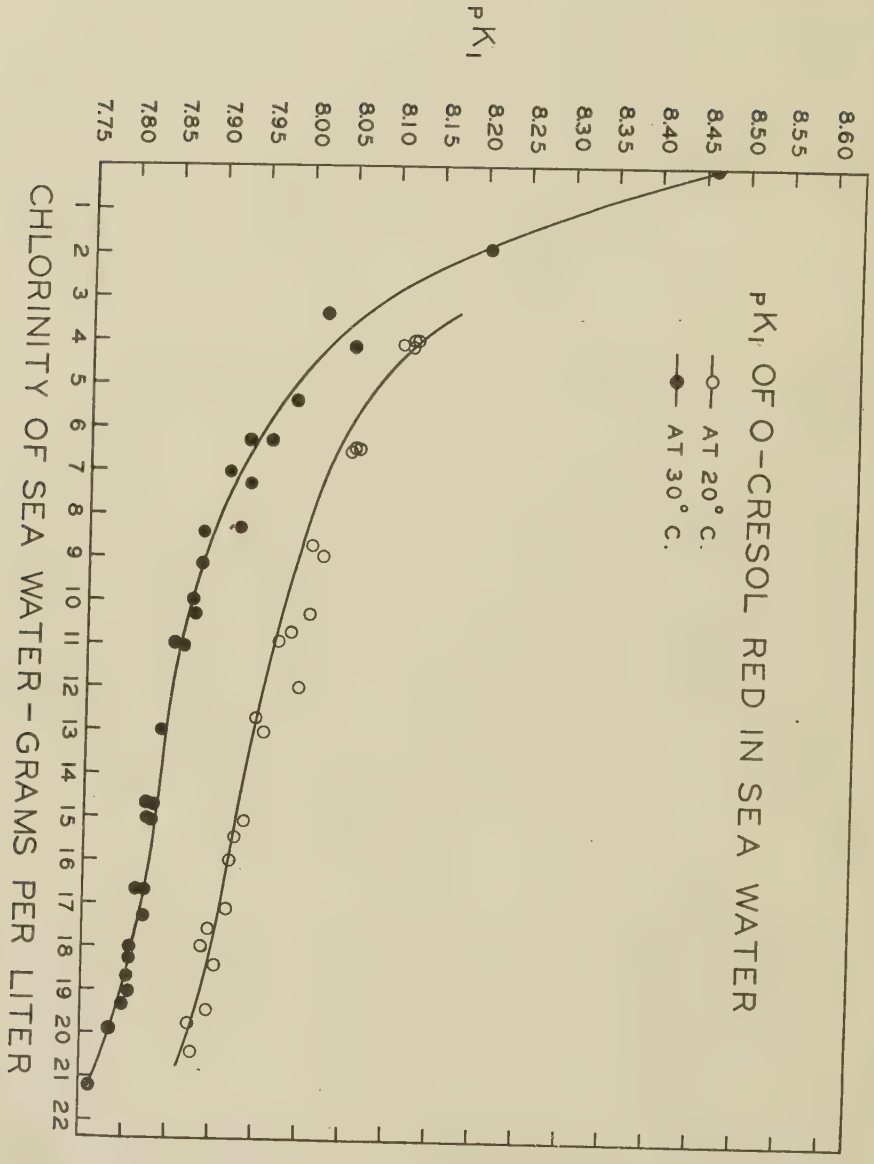
THE technical improvements during recent years in methods for colorimetric estimation of pH permit the attainment of results which exceed in precision and reproducibility the accuracy of available information concerning the behaviour of pH indicators as influenced by the ionic strength, specific ion effects, temperature and other conditions in the solutions to be measured. This discrepancy has been particularly noticeable in our experience with the pH bicolorimeter of the Hastings type. So far as the actual measurements are concerned, results would seem to justify computation of the pH to the third place of decimals. But the formula for computing,

$$pH = \log \frac{\text{depth of alkaline standard}}{\text{depth of acid standard}} + pK_I,$$

means that precision is limited by the accuracy of knowledge of the value for $pK_I$, the logarithm of the reciprocal of the dissociation constant of the indicator in the particular solution measured. This limitation has probably been encountered in many laboratories. We have met it in several instances. One of them is the estimation of the pH of sea water.

It therefore seemed advisable to undertake more accurate measurements of the so-called "salt effect" of sea water upon indicators and also of the temperature effect. The indicator chosen for an initial investigation was o-cresol red because it is now widely used for pH measurements on sea water.

Values already available are those given by Wells (1) and by Ramage and Miller (2). In neither of these investigations was the temperature effect established and in the work of Ramage and Miller, $CO_2$ was eliminated from the water by prolonged bubbling of hydrogen through it. The effect of removal of $CO_2$ upon the dissociation constant of the indicator is unknown.




We now have a satisfactory method for obtaining the pH of solutions quickly, accurately, and without any serious difficulties due to $CO_2$. This is by means of the glass electrode. Its usefulness in our experience with it was largely influential in our decision to undertake the work here reported. The form used has been described by Taylor and Birnie (3).

The procedure was as follows. Sea water samples were prepared

## Table 1.

**Dissociation Constant of o-Cresol Red in Sea Water at 30° C. and at 20° C.**

| Chlorinity | | pH by the glass electrode | $\log \frac{y-x}{x}$ (1) | $pK_I$ |
|---|---|---|---|---|
| grams per litre | grams per kg. | | | at 30° C. |
| 21.21 | 20.66 | 8.081 | 0.320 | 7.761 |
| 18.33 | 17.93 | 8.073 | 0.269 | 7.804 |
| 16.71 | 16.37 | 8.060 | 0.238 | 7.822 |
| 14.75 | 14.49 | 8.041 | 0.222 | 7.829 |
| 13.00 | 12.80 | 8.006 | 0.170 | 7.836 |
| 11.04 | 10.89 | 7.977 | 0.116 | 7.861 |
| 9.18 | 9.08 | 7.921 | 0.041 | 7.880 |
| 7.33 | 7.27 | 7.589 | 9.656 — 10 | 7.933 |
| 5.40 | 5.38 | 7.484 | 9.499 — 10 | 7.985 |
| 4.17 | 4.16 | 7.381 | 9.331 — 10 | 8.050 |
| 3.39 | 3.38 | 7.334 | 9.276 — 10 | 8.058 |
| | | | | at 20° C. |
| 20.43 | 19.92 | 7.939 | 0.060 | 7.879 |
| 18.41 | 18.00 | 7.942 | 0.039 | 7.903 |
| 16.00 | 17.69 | 7.924 | 0.005 | 7.919 |
| 13.04 | 12.84 | 7.919 | 9.965 — 10 | 7.954 |
| 10.96 | 10.81 | 7.886 | 9.916 — 10 | 7.970 |
| 8.98 | 8.87 | 7.832 | 9.813 — 10 | 8.019 |
| 6.44 | 6.40 | 7.710 | 9.652 — 10 | 8.058 |
| 4.08 | 4.07 | 7.544 | 9.442 — 10 | 8.102 |

[1]) Where $y$ = total depth of standards, $x$ = depth of acid one.

by diluting a given specimen with distilled water so as to have a series of varying salt-content checked at the end of the experiment by titration with silver nitrate. Each dilution was then allowed to come to equilibrium with $CO_2$ in a thermostat at the temperature to prevail during measurements. The pH values were then taken with the glass electrode and shortly afterward observations were made at the same temperature in the bicolorimeter with cresol red as indicator. The log of the ratio of the depths of the two standard colour solutions was subtracted from the corresponding pH to give the $pK_I$.

The cresol red employed was previously examined by the spectrophotometric method and found to give maximum absorption at a wavelength of 572 mμ and to exhibit an absorption curve which would characterize it as satisfactorily pure. The two standard colours, in the fully acid and fully alkaline condition, were obtained in (a) a phthalate buffer solution prepared after Clark and Lubs and having a pH 3.90 and (b) a borate buffer solution prepared according to Sörensen and having a pH 11.00.

An isohydric condition of the indicator is of course very important for any high degree of precision with slightly buffered solutions. In these observations, we found that for a chlorinity of the salt water less than about 10 parts per thousand seriously discrepant results were

reached unless the indicator solution was adjusted to approximately the same pH as the unknown, and the lower the chlorinity, the greater the necessity for accuracy of adjustment to an isohydric condition if concordant results were to be obtained. With higher chlorinities a considerable variation in the pH of the indicator solution made no difference in the result beyond the usual observational error. The buffering capacity of water of high salinity is sufficient to overcome that of the indicator itself. For the more dilute waters the E. M. F. of each sample as taken with the glass electrode served as a guide for adjustment of the indicator. A small portion of its solution was titrated with very small amounts of 0.001*N* HCl, tested in the glass electrode after each addition and finally adjusted until it gave a potential varying by not more than one millivolt from that of the water sample which was to be measured.

The $pK_I$ values obtained are shown in Table 1, and in the accompanying graph (Fig. 1). The results shown in Table 1 are those obtained in two typical series of measurements, one at 30° C. and one at 20° C. The results for both of these series and also those for other similar ones are presented graphically in Fig. 1. The point at 30° C. and zero chlorinity is taken from Kolthoff (4).

Our values at 20° C. are higher than those of Ramage and Miller who included values given by Wells, while our values at 30° C. are lower than earlier reported ones. But as temperature is not stated in the earlier reports, one may assume that it would account for some at least of the discrepancies. In the case of $pK_S/pK_I$ for all chlorinity values below about 9 grams per litre our results are all consistently higher than those of Ramage and Miller. This is due, presumably, to the fact that we used indicators isohydrically adjusted, for we found that using the ordinary indicator solution (prepared so as to make the monosodium salt) our results were as low as or even lower than those of Ramage and Miller.

As one can see from the graph, the $pK_I$ drops off sharply with increases in the lower range of salinities, decreases only gradually through the medium ranges and again falls off rapidly at salinities in the neighbourhood of those found in mid-Atlantic waters.

## Summary.

Values for the $pK_I$ of o-cresol red in sea water at various dilutions were obtained at 30° C. and at 20° C. by the use of the glass electrode and the bicolorimeter. The results are shown graphically.

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# Some Devices for the Manipulation of Marine Plankton Collections on Board Ship.

By

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IN the course of an oceanographical investigation off the west coast of Canada during 1934, it was found necessary to expedite the collection of net plankton and the subsequent filtration of the samples. The apparatus and methods developed in this connection may be of interest to those investigators who have found that the time factor is a very important consideration.

## Collection of Plankton with Closing Nets.

Previously, plankton samples in vertical series had been taken with a single closing net which was successively operated through different depth intervals. This procedure was too time-consuming and did not provide simultaneous samples.

In order to overcome these difficulties, a number of plankton nets, similar in design to that illustrated in Figure 1, were used in series.

The skeleton of the apparatus is a rod of wood or an iron pipe (a). The upper end is made fast to a suitable clamp (b), which is fitted with a releasing device and the lower end is fitted with an ordinary snap hook (c) on a swivel joint. The clamp is used to fasten the rod to the sounding wire and the hook ensures its vertical position at all times. On the side of the rod opposite the wire, two other snap hooks (d, d) are rigidly fastened, the one at the bottom end and the other at a position opposite the centre ring of the net.

The plankton net is rigged in the usual manner with the bridle at the top so adjusted that the upper truncated cone is held in position when the bridle is fastened to the release clamp. Small rings, fastened to the centre and the lower end of the net, serve to attach the net to the rod by means of snap hooks.

The release clamp (Figure 2) is made of cast bronze and of the illustrated dimensions. For convenience in attaching to the sounding line, the back is hinged on one side and held on the other by hinged

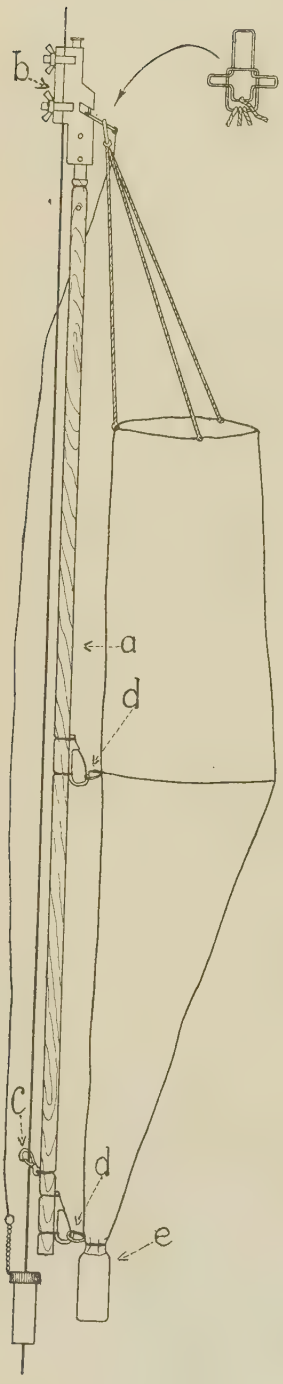


Fig. 1.

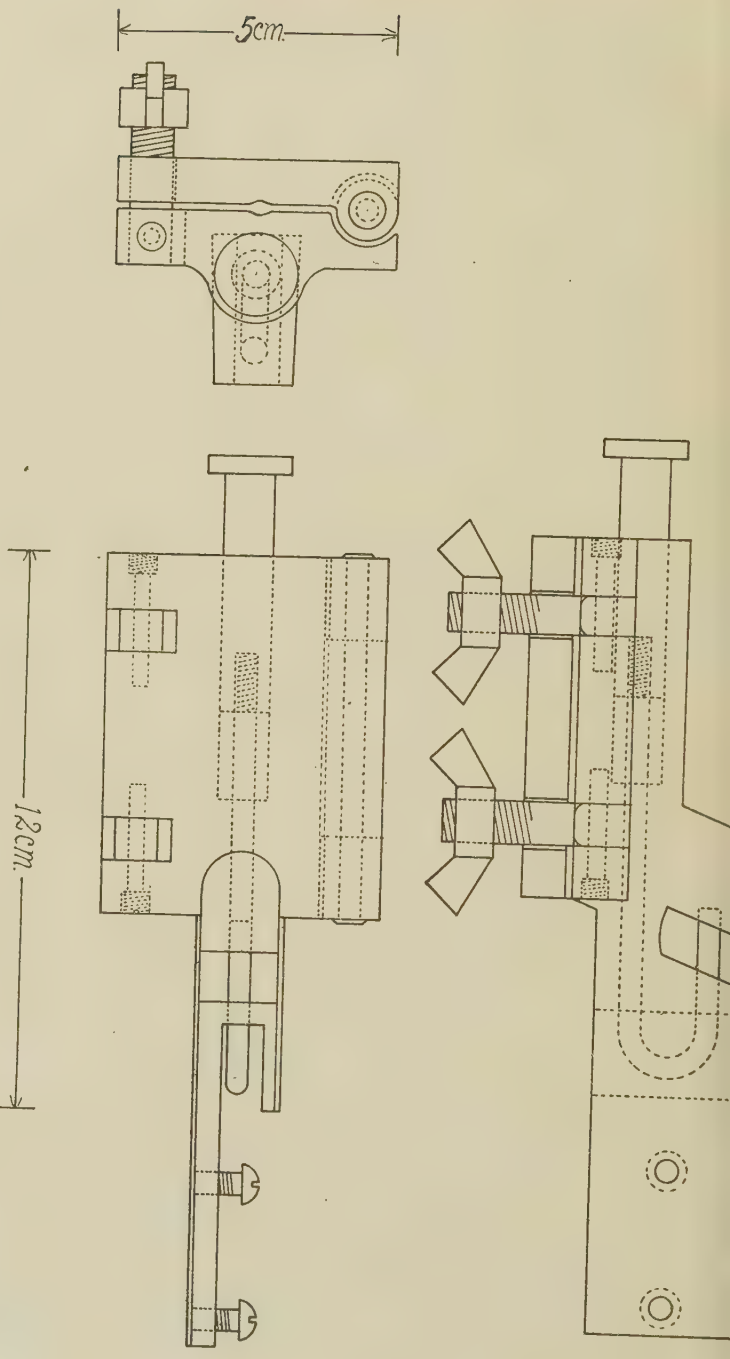


Fig. 2.

bolts which have a loose cut thread so that the wing nuts may be tightened by hand. The top of the plunger is mushroomed to prevent the possibility of the messenger slipping between it and the wire. A lug is used to attach the top end of the rod. Any suitable type of release clamp may be used, but the one shown has proved very satisfactory under the most trying conditions at sea.

If a column of water (e. g., 150 metres depth) is to be examined in three equal sections, the requisite number of nets (3) are attached to rods and placed in readiness on the deck of the vessel. At the proper time, the rods are attached to the wire by the snap hook at the bottom and the release clamp at the top, and placed in series at the predetermined intervals (50 metres). Messengers are attached to each, except the bottom net, as shown in Figure 1. (A convenient method of attaching the messengers is shown in the inset, Figure 1). The nets are then lowered to the desired depths, hauled upward through the predetermined interval (50 metres), a messenger released from the deck and the nets successively tripped. The whole outfit is then hauled on deck and taken from the line, the nets removed from the poles and hung in racks until the investigator can attend to the collection. In this manner the whole column of water is sampled in equal sections in one haul.

If it is desired to vary the interval through which the nets are hauled, a group of three or four are placed a long distance apart for the deep haul and when they are returned to the deck a fresh set of nets with their rods is instantly fitted to the cable and a second group of samples taken at smaller intervals from the shallower part of the column. In this manner it is found possible to divide a depth of 200 metres into nine intervals which may be sampled in three hauls: first haul, three nets 40 metres apart; second haul, three nets 20 metres apart; third haul, four nets 5 metres apart.

It was found convenient to use glass bottles in place of the usual silk-panelled buckets on the bottom of the nets. These were held in position by means of a ring clamp (Figure 1, e) and, when the nets were returned to the deck after a haul, the bottles were detached and removed to the laboratory for the further manipulation.

Apart from the increased rapidity of this method, there are several advantages to be gained, such as ease of handling and efficiency of performance. The nets are held open at all times by the rods and may be fastened to the line as easily as any deep-sea water-sampling bottle. Furthermore, the rod protects the net from damage by contact, and as a small weight may be used for a sinker (since the nets are held open by the rods) the strain on the fabric due to the plunging of the vessel in heavy seas may be minimized.

## Filtration of Phytoplankton Samples.

It is customary to collect the phytoplankton samples in a one-litre Ekman deep-sea water bottle, at the same depth from which the sample for water analysis is drawn. In a depth of 200 metres there

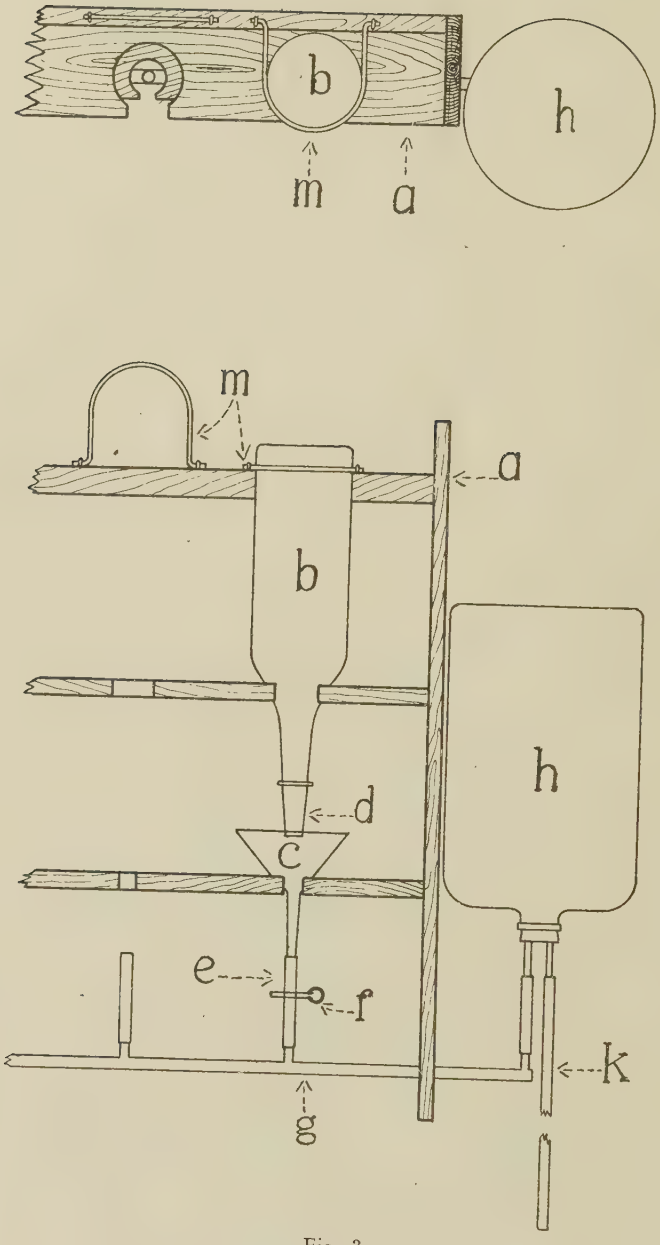


Fig. 3.

are eleven samples, each of which is passed through a hardened filter paper and the collected plankton counted. The tedium of filtering is obviated by the use of the illustrated apparatus (Figure 3).

A rack (a) is constructed to hold a number of bottles (b) containing the samples to be filtered and a similar number of funnels (7 cm. diameter) (c) in the position shown. A nipple (d) made from a short piece of rubber tubing of large diameter (15 mm.) is fitted over the neck of each bottle and adjusted so that, when the bottles and the funnels are in position, the end of the tubing is about one-half centimetre below the rim of the funnel. The stem of each funnel is inserted into a short length of rubber tubing (e) to which a stopcock (f) is fitted, and which leads into a (copper) tube (g) which is connected to the (four-litre) bottle (h) which is filled with water and served to maintain the suction. From this bottle a long piece of rubber tubing (k) leads to the waste drain or a bucket placed about one and a half metres below the level of the bottle.

The filters are fastened by revolving the edge of the funnel containing the folded paper in a shallow pan of melted, hard or laboratory wax, and the folded edge inside the funnel should be sealed with melted wax from a medicine dropper so that no plankton may get under it. If the paper is folded so that it touches the funnel only around the upper edge, the maximum filtration surface is exposed and the process is very rapid. If they are perfectly sealed into the funnels about one and a half metres of suction is sufficient. The bottom end of the suction tube should be placed under water to prevent air backing up the tube.

The sample to be filtered is placed in the bottle (b) and by pinching the rubber nipple (d), it may be overturned and placed in the rack (a) without spilling and then locked in position by means of the hinged ring (m). It is customary to transfer the sample directly from the Ekman water bottle to this bottle, which is numbered to correspond with the depth observed, and as each bottle has its own position in the rack there is no need for further adjustment of the nipples once the bottles have been put into service. By removing the pinchcock from the rubber tube below the funnel, the suction is started and filtration is allowed to proceed to completion when the suction is stopped by replacing the pinchcock. Very little attention is required on the part of the investigator, as notice that filtration is completed is sounded by the system "sucking air" through the empty filter. The plankton may then be washed off the filter paper by a stream of distilled water or filtered sea water from a wash bottle without removing the paper from the filter[1]).

It was found advisable to start the samples from the surface zone first as they usually take much longer to filter on account of the relatively large number of plankton organisms.

[1]) N. M. Carter and J. P. Tully. "Oceanographical Investigations of the Pacific Coast of Canada, Strait of Georgia: I. Methods." Journ. Biol. Bd. Can. In press.

This whole apparatus was securely fastened to the wall of the ship's laboratory where it functioned satisfactorily under all conditions found at sea.

The writer wishes to acknowledge his indebtedness to the Biological Board of Canada for the opportunity of taking part in the oceanopraphical investigation and to express his thanks to Mr. H. D. Parizeau, commanding officer of the C. G. S. "Wm. J. Stewart", the hydrographic survey vessel of the Canadian Pacific coast, for many courtesies. The writer is further grateful for the assistance of the chief engineer and his staff on board the vessel.

## Summary.

An apparatus is described by which any number of equal sections of a vertical column of water may be sampled simultaneously for net plankton. A plankton net for each section to be examined is attached to a rod of wood or an iron pipe, which in turn is fastened to the sounding wire by means of a release clamp and a snap hook. When these nets are set at equal intervals and the whole arrangement hauled through this interval, and the nets tripped, the entire column is sampled simultaneously and the time of operation reduced to a minimum.

A compact, automatic apparatus which enables the volume of phytoplankton samples to be reduced by filtration through paper, is described. A bottle containing the plankton sample is inverted into a funnel and suction is applied by gravity flow. The whole apparatus is fitted into a wooden frame and is peculiarly adapted for use on board ship.

# Note concerning a Measuring Plankton-Net.

By

**H. W. Harvey,**

Marine Biological Association, Plymouth.

A net of bolting silk, having a meter which measures the quantity of water passing into and through it during a vertical, oblique, or horizontal haul was constructed in 1933 and described (1). During two and a half years of regular use the apparatus has worked satisfactorily. The primary aim was to obtain a rapid measure of the phytoplankton population caught in a 200 mesh to the inch (No. 25) silk net. To do this the measuring net is attached to a leadline about 2 metres above the lead, lowered and hauled once or several times from surface to any desired depth. By means of a throttle and double release vertical hauls may be made between any two desired depths. The net fishes both while being lowered and while hauled through the water. Calibration of the meter showed an approximately linear relation between dial reading and quantity of water passed through the meter at speeds varying between 50 and 550 litres per minute, which allows considerable latitude in rate of hauling and in clogging of the net. The catch is washed into the bucket attached to the bottom of the net, poured into a measuring cylinder, formalin added, and an aliquot portion, usually 100 c.c. is then filtered through a disc of the same bolting silk. The disc, with plankton on it, is removed from the filter funnel, put into a small tube and covered with 3 to 5 c.c. of 80 % acetone. In the case of most species of diatoms the yellow green pigment dissolves in a few minutes, with other species such as *Coscinodiscus* in several hours. The acetone extract is then, if necessary, diluted with more 80 % acetone and its colour matched against a series of colour standards. Thus the pigment content of the phytoplankton caught per cubic metre of sea is rapidly evaluated in arbitrary units. It was found that a solution of potassium chromate and nickel sulphate gave an almost exact match in quality of colour, unless much pigmented zooplankton was also caught. A solution

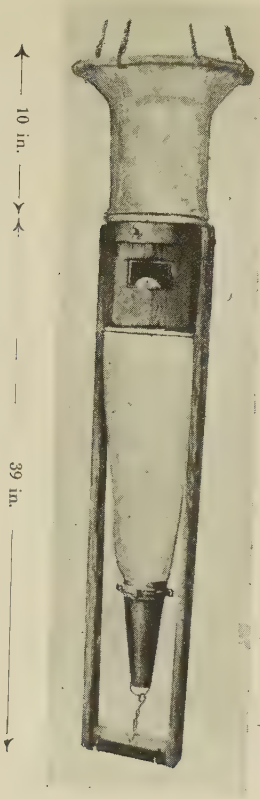


Fig. 1. Measuring net.

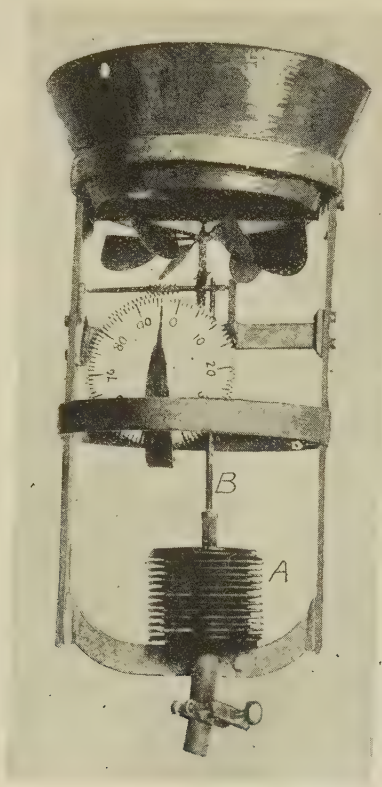


Fig. 2. Meter.

containing $25 \times 10^{-6}$ gm. $K_2CrO_4$ and $430 \times 10^{-6}$ gm. $NiSO_4$, 6 $H_2O$ was taken as containing one arbitrary "unit of plant pigments". Aliquot parts of the remainder of the catch have been used for counting the number of animals and plants (2). The method has now been used off Plymouth, in the Antarctic, and in the Indian Ocean. Rarely has any difficulty been met with in obtaining a colour match.

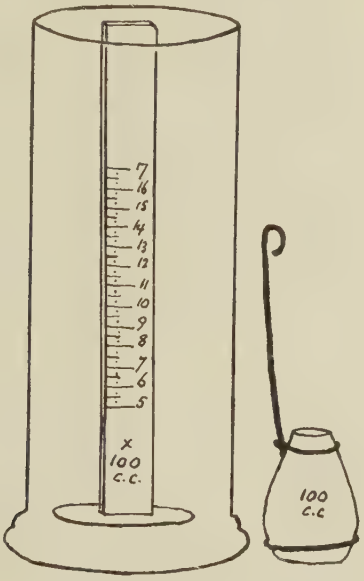


Fig. 3. Cylinder with dip stick calibrated in 100 and 25 c.c. Measure of 100 c.c. for dipping out plankton.

Several slight modifications have made the net, as originally described, more convenient for use at sea. Fig. 1 shows the apparatus with principal dimensions. The net of bolting silk is held in place in the frame by a short length of rubber elastic. Fig. 2 shows the meter, which can be readily withdrawn from the wood casing for inspection. A hydrostatic valve stops the meter revolving as the net is being lowered into and drawn out of the water. A single dial-wheel of 2 in. diameter with 100 teeth, and a pinion wheel with 12 teeth engaging the worm on the spindle of the rotor, have been found convenient. With the meter illustrated a unit division on the dial wheel corresponds to the passage of 25 litres of water. In place of an ordinary measuring cylinder, one having graduations marked on a central dip-stick (Fig. 3) was found easier to read at sea. By drawing the dip stick up and down, the brass plate forming its base kept the plankton in the cylinder well mixed, and a representative sample could be taken with the 100 c.c. measure.

With a very fine silk net the quantity of water filtered depends not only upon the distance the net is drawn through the water, but

also upon the speed at which it is drawn, the extent to which the meshes become clogged, the length of time the net has been in use, and whether the net has been wet for some time before a station is worked. Where quantitative catches are required, these variables are overcome by the use of a measuring net.

With nets of relatively large mesh the quantity of water filtered depends in the main upon the distance they are drawn through the water, provided the speed is reasonable and reasonably constant. For such it is probably sufficient to know the distance and the filtering efficiency of the particular net, in order to obtain a quantitative catch.

The filtering efficiency of nets of coarser mesh hauled vertically at a standard speed can be calibrated against a measuring net. Thus a rough calibration was made with a half-metre Coarse Silk Net of No. 3 silk (3). A number of vertical hauls were made at the same time and place with this and a measuring net which was fitted with silk of the same mesh for the purpose; several species of animals were counted in both net catches. From the ratio of these and the volume of water filtered by the measuring net, the volume filtered by the half-metre was calculated.

## Limitations of the method.

In order to evaluate the total phytoplankton population of the sea, the use of the finest nets suffers from the drawback that many of the smaller species get through. However, in many areas it appears that the greater part or bulk of the algal matter is retained, particularly if the water only passes slowly through the net, unless small species are dominant at the time.

For areas of sea where small forms are dominant, or for any exact measure of the phytoplankton population, the centrifuge or sedimentation method is necessary. Furthermore, since the phytoplankton is not evenly distributed, samples of water, derived from a large number of the relatively small samples taken with a water bottle, may be necessary for an exact evaluation by direct counting methods.

In considering the algal or "producer" population, the carbon (carbohydrate, fat, and protein) content of the phytoplankton is of most interest from the point of view of the fertility, rather than numbers and species, with their great differences in size between different species and considerable variations in size among the same species. The carbon content cannot be estimated rapidly, nor can the phytoplankton be readily separated from the zooplankton, except occasionally, for the estimation of this or other constituents. The measurement of the plant pigments, first used by Kreps and Verjbinskaya, seems at the present the nearest approach to the desired end; it can be made rapidly, with, if necessary, considerable accuracy. We do not know, however, if the relation of pigment content to carbon content varies materially in mixed phytoplankton populations in similar latitudes. During a survey made at a station in the English

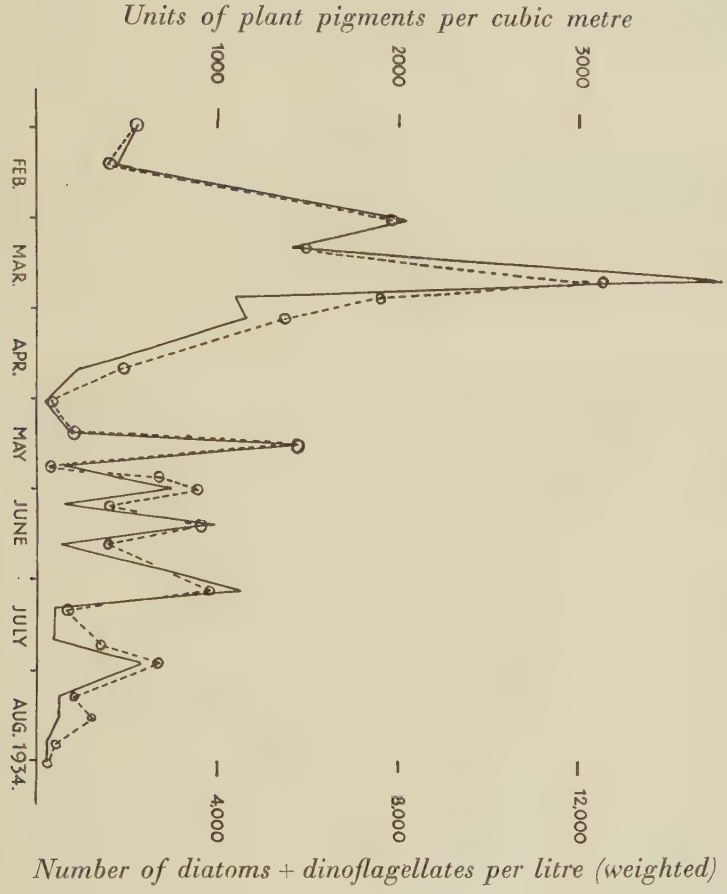


Fig. 4. Diagram showing relation found between numbers of phytoplankton organisms caught and plant pigment, at station L4 between surface and 45 metres. Points joined by continuous line show units of plant pigments in organisms caught per cubic metre of sea. Circles joined by pecked line show number of diatoms and dinoflagellates caught per litre of sea; these numbers are weighted, 20 *Skeletonema costatum* cells or 3½ *Rhizosolenia shrubsolei* or 3 *R. alata* being counted as one organism.

Channel during 1934, the diatoms and dinoflagellates in the catches were counted and their pigment content determined (2). The catches were made up of many species of widely varying size; if, however, allowance is made for the small size of only three species, a clear relation is seen between pigment content and number of phytoplankton organisms (Fig. 4). Later in the year when several species of *Chaetoceras* became abundant the clear relation ceased.

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(2) Cooper, Harvey, Lebour, and Russell. Journ. Mar. Biol. Assoc. In press. 1935.

(3) Russell and Colman. The Zooplankton. I. Gear, Methods and Station Lists. Great Barrier Reef Exped. 1928—29. Sci. Rep. Vol. II. No. 2. p. 7, 1931.

# A Note on Amoebae living in a Sea Water Sample.

By

**R. E. Savage, A. More** and **J. R. Lumby.**

AT 1.0 a. m. on 11th August 1934 a sample of sea water was drawn by means of the Surface Sampler at 54°5′N., 1°30′E.; there was a strong north-westerly wind, with rain squalls and a rough sea. On 26th November 1934, when this sample was examined, there appeared to be nothing defective about the bottle or stopper, but it was noticed that the sample contained a flocculent, dark brown sediment which showed no characteristic vegetable cellular structure with a $^1/_6$″ objective, and was found to contain much iron. In determining the salinity the titration was made three times, twice with the sample shaken up and later without stirring the deposit. The three determinations gave values of 22.34, 22.34 and 22.32 $^0/_{00}$ respectively, compared with values above 34.5 $^0/_{00}$ at neighbouring positions. It was not considered that the sediment would account for any material change in the salinity.

Part of the sample was returned to the Lowestoft laboratory for a more intensive microscopic examination of the sediment. This examination showed that the principal constituent was organic detritus; a few flagellates were swimming freely in the liquid and there were also some rod-shaped bacteria, and an occasional empty diatom frustule. A few strands of vegetable tissue (xylem) were noticed embedded in the detritus. In addition to these there were considerable numbers of amoebae creeping about amongst the detritus. We do not feel competent to identify the amoeba, but from the absence of a contractile vacuole in all the specimens we examined we came to the conclusion that it might be an *Entamoeba*. One of the writers had considerable experience during the Great War in identifying entamoebae from human stools, and is of the opinion that these entamoebae were similar to *Entamoeba coli* which is commonly found in human faeces.

The amoebae were of a pale green colour, between 20 μ and 35 μ in length, and moved sluggishly around the edges of the organic detritus. The pseudopodia were clear, generally blunt and narrow.

The amoebae may have come from three sources: 1. the atmosphere, e. g., when the bottle was opened; 2. the sea itself: they may be marine amoebae; and 3. bilge or other waste water pumped from the ship.

The pipettes used in the determination of salinity are connected with a mechanical suction apparatus and are suspended in air in closed bottles so that they do not come in contact with any solid or liquid substance between insertions in consecutive sea water samples. Moreover, since the absence of a contractile vacuole suggests that they are entamoebae, this alone appears to rule out both sources 1 and 2, leaving a distinct probability of the amoebae having come from source 3, even though this entails the assumption that entamoebae from the human intestine had survived for nearly four months in the free state in cold salt water.

Occasionally a sample of sea water is collected which, on analysis, proves to have a salinity differing somewhat widely from what might ordinarily be expected, considering the time and place of origin. Such values, besides being difficult to co-ordinate with the majority, would, if true, seem to indicate a state of affairs in the sea so unusual as to warrant the closest investigation, and it therefore becomes important to pay special attention to the question whether the values are trustworthy or not. It is difficult to justify their wholesale rejection merely because the values seem extraordinary; the assumption should be that they are correct, unless an examination of the circumstances of sampling shows at least a strong probability of their incorrectness. All widely aberrant results are confirmed by repeated analytical determinations, but errors may arise through inadequate arrangements for sampling and for storage after collection. In the case of samples from commercial and other ships, records of the state of weather at the time of collection may help in coming to a decision, and a sample likely to have been spoilt by a damaged and leaking storage bottle can usually be noticed at the time of analysis. The Surface Sampler was designed for the collection of sea water samples from ships under way, as an improvement on the bucket method of collection. Nevertheless, some responsibility still rests upon the observer using the apparatus, and deficiencies arising here are perhaps least readily noticeable.

In the present case the evidence — the low salinity, the presence of iron, the large quantity of detritus with some vegetable strands, the numerous amoebae (suspected of being entamoebae from human faeces) — strongly suggests that the sample of water was contaminated by bilge pumped from the ship, due to the Sampler having been towed too close to a discharge.

# Reviews.

**C. W. Correns, A. Defant, F. Gessner, W. Stahlberg, O. v. Schubert, H. Wattenberg** und **G. Wüst.** "Tiefseebuch. Ein Querschnitt durch die neuere Tiefseeforschung." E. S. Mittler & Sohn. Berlin, 1934.

This book, intended to present a cross-section of modern deep sea investigation in popular form, consists of seven independent sections, by different authors, treating as many different phases of the subject.

The first chapter, by Professor Stahlberg, on Germany's share in deep sea investigation, opens with a résumé of the various German exploring expeditions, to continue with a discussion of recent advances in the several fields of oceanography in which the author's countrymen have been most active. On the physical side, he outlines the developments that have led from the earlier concepts of oceanic circulation to the far more complex picture of laminary counter-drifts now current. On the biological side Dr. Stahlberg first discusses the contributions made by the biologists of the "Valdivia" expedition towards demonstrating that there exists a pelagic fauna peculiar to the mid-depths. The reader next meets a résumé of Victor Hensen's pioneer work, in quantitative plankton study, from his introduction of the method of vertical tows to his organization of the expedition of the "National", culminating in his classic reports on the latter. Among subsequent investigations of oceanic biology, the author emphasizes Lohmann's and Hentschel's studies of the more minute plankton organisms.

The second chapter, by Dr. v. Schubert, treats of the instruments and technical methods now in general use for sounding, for collection of bottom and water samples, for measurements of temperature and of currents, and for certain chemical determinations. Here the reader will find descriptions and figures of some standard makes of sounding machines (both wire and echo), water bottles, bottom samplers, reversing thermometers, and current-meters. Indirect methods now in general use for the calculation of ocean currents are discussed and there is mention of the familiar titration method for the determination of salinity. Biological technique is not included.

The third chapter, by Dr. Defant, is headed "Ist die Tiefsee in Ruhe". No one will dissent from the general line of argument leading the author to answer "No", though opinions may differ widely as to details of circulation in the deeper strata of the sea. Introducing the central theme with an account of the surface system of wind currents, the author points out why it is, by Ekman's theory, that wind-driven currents must be confined to a very thin surface stratum. This introduces the question, what forces are responsible for the motion that the thermal structure of the sea proves also to exist even in the deepest waters? Following a discussion (illustrated by experiments) of differences in the specific gravity of the

water as maintaining a closed circulation, Dr. Defant explains that it is the combination of salinity with temperature, and not the latter alone, by which surface water chilled in the subpolar belts is made the heaviest in the sea, so that dynamic circulation is extended to the greatest depths. We must refer the reader to the author's own account of how the expansion of this sinking water equatorward over the sea floor is directed by the contour of the latter; how, in particular, the increment from the Arctic is confined, while the route lies open for the increment from the Antarctic. The remainder of the chapter is devoted to discussion of the laminary drifts towards the tropics in intermediate depths, of water masses sinking in mid-latitudes north and south; and to some brief mention of the effects of the outflow from enclosed seas such as the Mediterranean and Red Sea in intensifying ocean circulation.

In the fourth chapter, on the fertility of the sea, Dr. Wattenberg first summarizes the great regional differences long known to exist in this respect (roughly indicated by the colour of the water), then traces the chain of dependence from largest animals down to smallest chlorophyll-bearing plants, thus bringing the reader to the concept (now familiar) that the abundance of oceanic phytoplankton chiefly depends on the amount of nitrates and phosphates in solution in the water. After brief description of chemical methods, the author then shows the general correspondence between the distribution of these nutrient substances in the North and South Atlantic and the quantitative distribution of plankton. The upwelling of rich water from the depths, responsible for concentrations of phosphate, Dr. Wattenberg describes as due to the prevailing winds off West Africa; as due to the deflective force of earth rotation in the contact zones between cold and warm currents, and as drawing, in the Antarctic, from mid-water from the north in combination with some increment from the Pacific. A section follows on the alternate depletion and re-enrichment of the surface waters in high latitudes with nutrients, as related to the seasonal flowerings of phytoplankton. The chapter closes with a brief discussion of gold in sea water, and of its possible biologic significance.

Dr. Gessner's chapter on "Was lebt in der Tiefsee" introduces the reader first to the several groups of unicellular planktonic organisms, emphasizing their vertical distribution. The vertical distribution of different colour-communities of animals is discussed in relation to the penetration of light into the sea. Bioluminescence, the author believes, serves its possessors chiefly for the recognition of their breeding mates. A section on the development of eyes in animals living at different depths introduces a discussion of some of the more bizarre morphological adaptations of deep sea animals, such as elongated tentacles, barbels, spines and fin rays; the elaboration of fishing apparatus as among ceratoid fishes; of the enormously enlarged mouths, elongate teeth and vastly distensible bellies with which recent collections of bathyplanktonic fishes have made zoologists familiar. Generally accepted reasons are presented why increasing pressure cannot be considered a limiting factor, except for certain groups of fishes. And some of the indirect effects of the abyssal environment are finally considered, such as the reduction of limy skeletal parts and the contrast between the wide distribution of some deep sea animals contrasted with the development of local faunae in the case of others.

Dr. Correns's chapter, on the composition of the bottom, is limited to depths greater than 2440 metres, the deep sea being thus defined on the basis of Kossinna's hypsographic diagram. After sketching the development of methods for collecting bottom samples, and also mentioning some

of the recent results of echo sounding, the author first considers the organic sediments, commencing with the distribution of Coccolithophorids and of Foraminifera in the Atlantic. Discussion follows of the relationship between the accumulation of calcareous deposits on the sea floor and the richness of the water in dissolved lime as determined by pressure and by $CO_2$ tension, leading to the conclusion that it is this chemical factor that chiefly controls the percentage of lime in deep sea deposits. The author next shows how differences between the distribution of living species of Foraminifera in the water, and of their dead shells in the bottom oozes, combined with differences in the percentage of lime at different distances down into the ooze, point to lower temperatures in the South Atlantic in the last glacial period, but to little change in the current system.

Dr. Correns's discussion of inorganic sediments proceeds from a review of methods to an outline of the various sources from which inorganic sediments are derived and of the routes along which they reach their eventual resting places on the sea floor. An account of the Red Clay, based on the author's own investigations, is followed by a table from familiar sources showing the bottom areas occupied by the different classes of sediments. Finally, the author suggests that methods developed for the investigation of deep sea clays may prove of practical value to the ceramic industry.

The final chapter, by Dr. G. Wüst, on "Das Golfstromproblem" is divided into four sections. The first, on the Gulf Stream as a surface phenomenon, opens with the indirect ways (ships' logs and distribution of temperature), by which knowledge of ocean currents has come, quoting as the outstanding example of the direct method Pillsbury's current measurements of half a century ago, from the "Blake". The author next shows how greatly modern charts of the Gulf Stream differ from the first representation of the latter by Benjamin Franklin. Pointing out that the chief circulatory features in the Atlantic are the equatorial currents, south and north, he next traces the latter, *via* the Caribbean and Gulf of Mexico to its outflow at greatly increased velocity through the Straits of Florida. For the entire current northward and eastward across the Atlantic, to its multiple furcation in the eastern side, he adopts Iselin's term "Gulf Stream System", pointing out that Gulf Stream velocities -- except in the Straits of Florida — are much lower than earlier supposed. The role played by the System in maintaining high water temperatures over north-western Europe is next discussed. The second section emphasizes the great thickness of the Gulf Stream System, it being fundamentally a dynamic current, with little diminution of velocity down to 600 metres, whereas but little trace of the wind-driven equatorial drift is to be seen at a depth of 200 metres. The third section presents a résumé of Dr. Wüst's own earlier dynamic study of water and heat transport through the Straits of Florida. The final section on "Golfstrom und Wetter" discusses the complex relationship that undoubtedly exists between periodic variations in the transport of warm water across the Atlantic by the Gulf Stream, and climatic conditions in western Europe.

The book is well written throughout, and well illustrated. The only adverse criticism the reviewer must offer is that, being chiefly limited to the scientific activities of a single Nation, and to the Atlantic alone, for illustrative material, it presents a somewhat one-sided picture of the present state of knowledge, and of the paths that have led thereto.

*H. B. B.*

**E. Le Danois.** "Les Transgressions Océaniques." Rev. Trav. Office des Pêches Marit. T. VII, Fasc. 4. Paris, 1934.

The complete theory, which the author has been developing during the past 15 years, is set forth for the first time in a single paper. Le Danois sought at the outset of his investigations to explain both the fluctuations of the fisheries and the periodic invasions of relatively saline water which he had encountered off the coast of Europe and on the Newfoundland Banks. More recently he has not only applied his transgression theory to the present-day general North Atlantic circulation, but also suggests that it is a major cause in past climatic changes. The scope of the theory is so wide that it should be considered seriously by all who have an interest in oceanography.

Le Danois first classifies the waters of the Atlantic on the basis of salinity. For his transgression theory the most important groups are equatorial water ($> 35.5\ ^0/_{00}$), Atlantic water ($> 35.0\ ^0/_{00}$) and water of polar origin ($< 35.0\ ^0/_{00}$). He next shows that the Atlantic water and the less widespread equatorial water exist as huge lenticular masses, with their greatest thickness in the Sargasso Sea and with their shallow, wedge-like margins inclined in a north-eastward direction. Since the Atlantic water does not mix readily with the polar water, expansions and contractions of the former produce marked changes in temperature and salinity along a boundary extending, on the west, from the Grand Banks towards Iceland and, on the east, along the edge of the European continental shelf. Between the Grand Banks and Cape Hatteras the boundary of the Atlantic water coincides with the Gulf Stream, which the author considers as being unimportant as a current east of longitude 40° W. Thus the north-eastern sector of the ocean receives the major effect of the expansions and contractions of the Atlantic water. A period of expansion is termed a transgression; a period of contraction, a regression.

These periodic movements are explained as being caused by astronomical phenomena. Thus there is a major cycle of 111 years, corresponding to the displacement in latitude of the sun spots. Shorter cycles of 18.6, 9.3, 4.6 years are superimposed and exert successively smaller influences on the transgressive movements. Since the year 1885, the major cycle has been declining in intensity, but will increase again after 1939. Of recent years, 1903 and 1921 are representative of the 18-year maximums, while 1912 and 1930 were minor peaks of the 9-year period.

Continuing with this line of reasoning, the author suggests that very much longer periods of cosmic origin will explain the glacial and interglacial climatic changes.

The current system of the North Atlantic is next considered in its relation to the transgressive movements. Four currents only are discussed. The Labrador Current is described as exerting its influence as far south as Cape Hatteras and as being held close to the North American coast by the rotation of the earth. The relative freshness of the Equatorial Current is thought due to the westward movement of coastal water from Africa. In the case of the Mediterranean Current, the author considers that it plays only a minor role in supplying relatively saline water at mid-depths in the eastern North Atlantic. Likewise he finds that east of the Grand Banks the Gulf Stream becomes indistinguishable from Atlantic water and therefore argues that it is relatively unimportant in the north-eastern area compared to the transgressive movements.

The remaining, considerable section of the paper is devoted to a study

of the variations in north-eastward penetration of relatively saline water along the eastern margin of the ocean. Shallow tongues of northern and southern water are traced on numerous charts, the region being broken up into six subdivisions. As far as possible the observations from different years in each area are considered in relationship to the periodicity of the transgressions of Atlantic water.

Such a thorough exposition of the evidence for periodicity in the sea is undoubtedly of major importance, because this is a phase of the circulation problem which has not yet received much attention. Not only is this question of commercial importance from the standpoint of the fisheries, but also it should be seriously considered in relationship to our present understanding of ocean currents. The obvious criticism which will be applied to Le Danois's work is that he has failed to take into account the structure of the ocean which results from the effect of the earth's rotation on water arranged in stable layers. In other words, we now know that the day is long past when currents can be successfully studied by means of surface observations alone. In the eastern North Atlantic especially, the wind must play an all-important part in the superficial movements and these frequently differ in direction from the deeper lines of flow. However, in spite of the fact that these important aspects of the problem have been neglected by the author, he has put forward a fresh point of view which, at least in part, can be incorporated without serious difficulty into the modern accepted theory of ocean circulation. *C. I.*

**A. Defant** und **O. v. Schubert.** "Strommessungen und ozeanographische Serienbeobachtungen der 4-Länderunternehmung im Kattegat 10.—17. August 1931." Veröff. Inst. Meereskunde. N. F., Reihe A, H. 25. Berlin, 1934.

These two memoirs are concerned with the analysis and discussion of the observations taken in the southern part of the Kattegat during August 1931, according to a programme arranged by the Conseil International pour l'Exploration de la Mer. Five ships, viz. two German ("Hunte", "Poseidon"), one Danish ("Japetus Steenstrup"), one Swedish ("Skagerak") and one Finnish ("Nautilus"), took regular observations at frequent intervals from positions at anchor, and special observations were also taken at certain Danish and Swedish lightvessels and coastal stations. This is the first occasion on which so many ships have worked simultaneously in so small a region.

The objects of study were the interchange of water between the North Sea and the Baltic, the mixing of the different kinds of water, and the phenomenon of internal waves. The observations were all good and without serious gaps, but they were made with dissimilar instruments and their interpretation is not always free from uncertainty. The work of analysis under review was carried out at the Institut für Meereskunde, Berlin. It shows that the region is one of great mixing and that it is not well adapted for a first study of some of the questions at issue. It has proved impossible to separate errors of observations from irregular oscillations and turbulent motions.

The first memoir is by A. Defant and is on the observation of currents and surface-levels. The observations taken on the "Hunte" are first considered separately and then all the other observations bearing on each topic are considered together. The oscillations in the direction of the "Hunte" itself are examined, but it is assumed that they have little influence on the

readings of the current-meters. These readings were taken at every five metres down to the bottom, which is at a depth of about 30 m. At each depth the chief tidal constituents and the residual current are isolated. For the variations of the residual current at the "Hunte", the wind is regarded as an important factor. Except near the level of the maximum density-gradient the vertical distribution of residual current is very similar to the theoretical distribution of Ekman for a landlocked sea. The residual current, however, shows great changes from ship to ship. The vertical distribution of semidiurnal tidal current shows rapid changes near the level of maximum density-gradient, and the phase becomes progressively earlier as the bottom is approached. The mean distribution for all ships is used to determine the magnitude of the internal waves (in phase with the surface elevation but 100 times as great), and an effective coefficient of turbulent viscosity ($\nu = 100$ cm.$^2$/sec.). The mean tidal current between surface and bottom shows good agreement from ship to ship. It is this mean which is associated with the oscillation of the surface, and the latter part of Defant's memoir is concerned with these ordinary tides. Co-tidal and co-range lines are drawn for the $M_2$ constituent over the whole of the Kattegat and then a satisfactory dynamical explanation of this constituent is given by the method for narrow seas which is now familiar.

The second memoir is by O. v. Schubert and is mainly on the observations of salinity and temperature, of which there were well over 20,000. The meteorological situation, however, is first considered and the non-tidal changes in the surface-elevation are attributed chiefly to the action of wind. The currents through the Great Belt and the Sound are studied, both from surface elevations and from meter observations, and it is shown that though the direction of these currents changed from time to time, it practically never changed between surface and bottom at the same time. The calculations of large scale water-movements appear to be quite satisfactory, but the current observations taken at the individual ships are so different one from another, as to indicate a very complicated circulation system. The changes of salinity and temperature, both with position and with time, are very great and the vertical distributions of the two elements show different structures. The S-T diagram indicates the presence of water of three different kinds, one near the bottom from the North Sea, one near the surface from the Baltic and a third in the intermediate layers, which is not a simple mixture of the other two. Non-periodic changes are separated from periodic changes and both are studied in great detail. The diurnal oscillations have the same order of magnitude as the semidiurnal oscillations, but the only oscillation not attributed to tidal causes is the diurnal oscillation of temperature near the surface. The maximum amplitudes of the semidiurnal oscillations of salinity reach the value 0.88 $^0/_{00}$ and those of temperature the value 0.41° C., but the two do not occur at the same depths. The phases of these semidiurnal oscillations become earlier with increasing depth, and in fact, the phases at 30 m. are, on the whole, 6 hours earlier than those at 15 m., the change being gradual. Both for non-periodic and periodic changes, vertical circulation systems are postulated, in which there are opposite circulations in the upper and lower layers, as it is concluded that these changes cannot be directly attributed to horizontal oscillations of masses of water.

The diurnal oscillation of surface temperature is found to have a mean amplitude of 0.29° C. with its minimum at 7 hr. and its maximum at 15 hr.

*J. P.*

**O.-H. Felber.** "Oberflächenströmungen des Nordatlantischen Ozeans zwischen 15° und 50° n. B." Aus dem Arch. Deutschen Seewarte. B. 53, Nr. 1, Hamburg, 1934.

The frequency of current-directions and their mean velocities may be represented by current-roses. If the resultant current is calculated from all observations carried out in, for instance, a one-degree square for a specified month, a representation may be given of the general surface circulation by drawing on monthly charts arrows for each one-degree square, indicating mean velocity, direction, and stability of the resultant current in that area. Both methods have been followed in the Atlasses and Tables for the Atlantic Ocean, published by the Royal Dutch Meteorological Office.

Making use of these data O.-H. Felber has gone a step farther and has drawn surface streamlines, taking into account the stability of the resultant current per one-degree square, the number of observations, and the distribution of the surface temperature. In this way twelve monthly charts for the general surface circulation have been constructed for the region between 15° and 50° N. lat., where numerous Dutch observations were available.

With the charts the author gives a survey of the various current regions and deals more especially with the Equatorial Current, the Gulf Stream, the Canary Current, and the position of the most important lines of convergence, viz., that to the south of the Newfoundland Bank and the sub-tropical line of convergence. Moreover the deviation of the surface current from the mere wind-drift has been discussed.

There is something attractive in representing the surface movement by plotting streamlines; I fear, however, that the streamlines give a flattering idea of our knowledge and that the movement, which — as the author remarks — will often deviate from the given representation, is in reality far more complicated. Consequently the representation may become misleading.

From the long arrows, drawn in the region to the south of Newfoundland, the student may deduce a direct connexion between Labrador Current and "Cold Wall". As regards this we may draw attention to *Koninklijk Nederlandsch Meteorologisch Instituut* nr. 102. *Mededeelingen en Verhandelingen* 35. "Surface Temperature in the Northwestern part of the Atlantic Ocean, 1933." It appears from both current and isotherm charts in this publication, that a direct connexion between both regions, anyhow in October and November, does not seem probable.

As far as the shifting of the position of the lines of convergence in the course of the year is concerned, this may be deduced as well from the current-arrows as from the streamline charts.

*P. M. van Riel.*

**H. B. Hachey.** (a) "Movements Resulting from Mixing of Stratified Waters." (b) "The Replacement of Bay of Fundy Waters." (c) "Tidal Mixing in an Estuary." Journ. Biol. Board Canada, Vol. 1, Nos. 2 and 3. Toronto, 1934 and 1935.

In these papers various problems are treated with reference to the hydrographical conditions in the Bay of Fundy and its estuaries. The papers are referred to below as (a), (b) and (c). In (a) the author reports on some experiments carried out in a tank 180 cm. long, 10 cm. wide and 13 cm. high. At one end of the tank was placed a wooden cylinder capable of

being rotated and so mixing stratified water in the tank. It was shown that a mixed water was produced with a density somewhere between the densities of the upper and lower water strata in the tank and that this product gave rise to an intermediate current away from the place of mixture, as well as to currents in the upper and lower layers towards the place of mixture.

The experiment was modified to permit an inflow of water of low density at the place of mixture. This resulted in a movement in the upper layer away from and in the lower layer towards the place of mixture. The experiment was further modified by letting a blast act on the surface towards and away from the place of mixture, so that different forms of circulation could be obtained.

The experimental results were compared with observations of currents in the Passamaquoddy Bay and were found to illustrate the principal features observed in nature.

In (b) the author has attempted to use the variation with depth of the annual range of temperature at a certain station in the Bay of Fundy as an indicator for the replacement of the water of the bay in the years 1924—1930. As far as the reviewer has understood it, the idea has been that the exchange between the water strata may be taken as analogous to the periodic flow of heat in one direction and that the replacement of the water in the bay must be correlated with the exchange between the water layers. The exchange of water between the layers and the conduction of heat may certainly be regarded to some degree as analogous. It must be borne in mind, however, that the exchange between the water layers is highly dependent on their stability and may therefore be of differing orders of size in the summer and in the winter. Separate investigations into the maximum and minimum temperatures at different depths might perhaps have given a clearer conception of the conditions.

The author has found some interesting correlations between the differences in the annual range of temperature for the intervals of depth from 0 to 20 m. and from 20 to 90 m., and also between these differences of range, the inflow of fresh water, and the prevailing winds. The differences in the annual range of temperature lie between —0.10° and 1.79° only and it would seem of importance to have the correlations subjected to a closer examination with more material, which should also permit an examination to be made of the variations occurring occasionally.

In (c) the author has studied the mixing of the waters in the estuary of the Saint John River and the influence of the mixed product on the water masses in the Bay of Fundy. It is evident that the high tides in the Bay of Fundy in combination with the configuration of the mouth of the river provide extraordinarily good conditions for mixing the salt and heavy water from the bay with the fresh water from the river. Diagrams showing the distribution of the different kinds of water arising from the mixing are given.

Undoubtedly the hydrographical conditions in the Bay of Fundy are rather complicated. It would be useful to devise further investigations to obtain a clear picture of the exchange of water in the bay. Such studies would be of common interest.

*J. P. Jacobsen.*

**G. Kobe.** "Der hydrographische Aufbau und die dadurch bedingten Strömungen im Skagerrak." Veröff. Inst. f. Meereskunde N. F., Reihe A, H. 26. Berlin, 1934.

In this paper a survey of the hydrographical features in the Skagerak is founded upon the German and Swedish observations taken on the quarterly cruises during the years 1902—12. These observations — from 18 stations with 12 of the stations situated in 3 sections — are published in the *Bulletin Hydrographique* and some of them were used for the construction of sections in that publication showing the hydrographical conditions at the time of the different cruises. In the present paper the observations are used for computing mean values of temperature and salinity for the periods 21.—23. February, 10.—11. May, 11.—19. August and 14.—19. November.

On the basis of the computed means a study of various problems connected with the hydrography of the Skagerak was undertaken. The main problems treated are (1) the formation of the water masses in the Skagerak from different characteristic components, and (2) the currents originating from the distribution of the density in the whole body of water in the Skagerak.

The author distinguishes between the following characteristic water masses in the Skagerak: (a) water with low salinity ($< 32\ ^0/_{00}$) from the surface to about 50 m. off the Swedish and Norwegian coasts; (b) "Bank" water with salinities between 32 and $34\ ^0/_{00}$; (c) North Sea water with salinities between 34 and $35\ ^0/_{00}$ in the upper layers along the Jutland coast, and (d) oceanic water with salinities of about $35.1\ ^0/_{00}$ in the depths of the Skagerak.

The author has studied in detail the occurrence of these water masses at the different seasons and has tabulated their percentage amount in the sections and at the surface for the different seasons. For three stations, D 10, S 8, and S 13, in the westehn, central, and northern parts of the Skagerak respectively the seasonal temperatures and salinities are tabulated for the several kinds of water that could be identified. Tables of the annual ranges and the means for these temperatures and salinities as well as some suggestions regarding the currents are given.

The author states that it has been necessary to make use of different methods in order to get a sufficient insight into the complicated hydrographic features. The methods used have been to construct (a) horizontal sections for temperature and salinity at the depths 0, 20, 50, 100, 200, 300, and 400 m., (b) three vertical sections each containing four stations, and (c) diagrams for the temperature-salinity relation at different stations. Among various details it may be mentioned that the author has found that the bank water with salinities from 32 to $34\ ^0/_{00}$ is not always of the same nature, and may be formed in different ways. Further that the six-monthly period in the temperature cannot be fully explained.

The problem of computing the currents from the distribution of the densities is treated in the usual way according to Bjerknes's method. Sections and charts showing the density of the solenoids and also the calculated currents are given. The results are discussed and compared with the few known facts relating to the actual currents. It is shown that the currents originating from the density distribution can account to a small extent only for the currents actually found.

The author discusses the water balance set up, on the basis of the calculated currents carrying water to and from the Cattegat. It has not been possible to obtain decisive results on this problem. In considering the

water balance the currents caused by wind and pressure must also be taken into account.

A solution of all the questions connected with the exchange of water between the Skagerak, the North Sea, and the Cattegat has not been possible for want of material. It is, however, of great importance that the material hitherto collected has been worked up and presented in such form that it may easily be used for further study.

*J. P. Jacobsen.*

**H. R. Seiwell.** "The Distribution of Oxygen in the Western Basin of the North Atlantic." Pap. in Phys. Oceanogr. and Meteor. Vol. III, No. 1. Cambridge, Mass., 1934.

In this report the author describes the oxygen distribution in the North Atlantic Ocean west of the 40th meridian and south of Nova Scotia. The account is based on the observations made during three cruises of the "Atlantis" in 1931—1933, and on such earlier data as are available. Six sections are described; they give the oxygen distribution expressed as a percentage of saturation and as c.c. per litre, and show the isotherms and isohalines. The observations were made to a depth of 3000 m.

The water is richest in oxygen near the surface, poorest in mid-depths, and rich again in the underlying strata. The author describes the horizontal distribution in these layers with the help of a series of charts.

As a rule the oxygen-rich surface layer is one in which there is only a weak temperature-depth gradient; as soon as a thermocline is reached the oxygen content of the water decreases. The extension of the layer downwards into the thermocline at one or two stations near the equator is believed to be due to particularly active photosynthesis taking place in the thermocline. The depth of the surface layer in which the water is more than 60 per cent. saturated with oxygen varies from about 100 to 800 m. in the region described; its depth is least in 10° S., and in the coastal region.

The oxygen content of the deep water is least in 10°—15° N., where the thickness of the oxygen-poor layer in which the water is less than 60 per cent. saturated is 1100 m. The layer shrinks almost to nothing at several stations in the northern part of the region, and to 900 m. near the equator.

In the underlying oxygen-rich layer the vertical and horizontal differences are smaller than those at lesser depths. Below 1500 m. the oxygen content increases from east to west, which is in agreement with Wattenberg's observations that the water in the western part of the Atlantic Ocean contains more oxygen than that in the eastern part. This is credited by Wattenberg to the better conditions in the western basin for the development of deep currents rich in oxygen, and to its lesser plankton population. The author does not entirely accept this explanation, on the grounds that Bigelow and Leslie (1930) have shown that in estimating the effect of respiration and organic decomposition the larger animals, above the size of copepods, are more important than the smaller species, estimated by Hentschel, that form the basis of Wattenberg's conclusions.

The investigation of seasonal changes of oxygen content shows that the most significant changes are confined to depths less than 100 m. and to the northern part of the region. Complete saturation was frequently recorded for the surface water, but in the northern part of the region in winter the surface water was found to be only 90—95 per cent. saturated.

In the second part of the report the author uses his data to calculate the speed of the deep water movements and the annual consumption of oxygen in the different layers. From a study of the salinity anomalies he shows that most of the water in the oxygen-poor layer north of 18° N. has its origin north of 50° N., whilst that south of 12° N. comes from the South Atlantic. The curve giving the decrease of oxygen from north and south towards the mixed water region shows that in both south- and north-flowing currents there are alternating regions of high and low oxygen content. It is assumed that the water in a region of high oxygen content has left the surface at the season of maximum oxygen content, and that in a region of low content at the season of minimum oxygen content. From the distances between regions of high content, and between regions of low content, in this and in the underlying layer, the author shows the existence of deep currents of 1—2 cm. per sec.

The author's subsequent calculations lead to the conclusion that the low oxygen content of the mid-stratum compared with the underlying water is the result of greater oxidation, and not of a slower renewal of oxygen.

*G. E. R. D.*

**B. A. Skopintzew.** "Bestimmung von kleinen Jodidmengen in Gegenwart von viel Chloriden und Bromiden." Zeitschr. f. anal. Chem. Bd. 92, H. 5 u. 6. München, 1933.

"The Determination of Iodine in Sea-water." Trans. Oceanogr. Inst. Vol. 3, No. 3. Moscow, 1933. (In Russian, English summary).

Of all the determinations the chemist is called upon to make upon sea water that of iodine is amongst the most difficult. The history of the determination of small amounts of iodine, in no matter what, is characterized by the failure of each fresh investigator to make the methods of his predecessors work without modification more or less drastic. Small details of manipulation with difficulty expressed in words are all important. In 1929 J. F. Reith introduced a method which in his own hands gave good results, but Skopintzew, whose fortune was shared by the reviewer, found it unreliable. Losses of iodine occur during extraction of the sea salt with alcohol and during the glowing of the second alcohol extract. If this be too weak, organic matter is not destroyed; if it be too strong, iodide is volatilized. Skopintzew has worked out a method that avoids both these sources of error and it will be of interest to see whether future investigators, true to tradition, will need to make still further changes. When bromine is used as oxidizing agent, several of the oxidation-reduction potentials involved are so close together as to make very close control necessary:—

$$\begin{aligned} \varepsilon_0 IO_3'/I' &= +1.08 \text{ Volts} \\ \varepsilon_0 Br_2/Br' &= +1.10 \\ \varepsilon_0 IO_3'/I_2 &= +1.17 \end{aligned}$$

The paper in German makes no mention of sea water as such and omits the preliminary separation of calcium and magnesium with alkali and of the bulk of the chlorides with alcohol. For the rest of the procedure, however, it is much the more explicit and apparently the more accurate.

The following is a composite summary of the method drawn from the two papers, to both of which reference should be made for details on the analysis of sea water. Iodate already present in the water is first reduced by acidified sodium bisulphite. The water is rendered alkaline and the precipitate of calcium and magnesium carbonates and hydroxides removed. The solution is then evaporated until salts begin to separate and alcohol added to bring down most of the chlorides. The alkaline alcoholic filtrate is evaporated and the residue taken up in distilled water and treated with chameleon (= potassium manganate or permanganate?) at the boil. (In the English summary of the Russian text the excess of permanganate at this stage is destroyed by hydrogen peroxide). In the German version the solution is brought to pH 2.5—3 with the aid of bromphenol blue. Addition of oxalic acid to reduce the excess of permanganate must then be made without delay since otherwise $MnO_2$ may separate in quantity. The pH is then brought back to 4.5 with sodium acetate and the solution again boiled. Finally are added potassium iodide, starch, and more acid, and the liberated iodine is titrated with 0.001*N* sodium thiosulphate. Accurate control of pH at each stage of the operations is essential to success.

*L. H. N. C.*

**D. Phifer.** (1) "Seasonal Distribution and Occurrence of Planktonic Diatoms at Friday Harbor, Washington." Univ. of Washington Publ. in Oceanogr. Vol. I, No. 2. Seattle, Wash., 1933.

(2) "Vertical Distribution of Diatoms in the Strait of Juan de Fuca." Ibid., No. 3, 1934.

(3) "Phytoplankton of East Sound, Washington, February to November, 1932." Ibid., No. 4, 1934.

(4) "Periodicity of Diatom Growth in the San Juan Archipelago." Proc. Fifth Pacific Sci. Congress, 1933. pp. 2047—9. Toronto, 1934.

This series of papers deals with the phytoplankton of the Strait of Juan de Fuca, a deep channel connecting the inland marine waters of Washington with the Pacific Ocean at Cape Flattery. It separates Washington from Vancouver Island, extending in an east-west direction from Cape Flattery to Race Rocks, with an average width of over ten miles. Eastward from Race Rocks it extends east-north-east for thirty miles, with an average width of over eighteen miles, connecting northward with Georgia Strait through the channels of the San Juan Archipelago and connecting southward through Admiralty Inlet, which in its north-eastern part enters Puget Sound.

The main problem discussed is the annual production of phytoplankton, especially diatoms, in the San Juan Archipelago. In a quantitative study by the centrifuge method it was found that there are at least two types of annual cycles of phytoplankton production in this region, the first, that of the main channels, the second, that of long narrow bays. In the main channels the phytoplankton maximum, instead of beginning in March or early April, which might have been expected, is delayed until May, in spite of the fact that there is an abundance of nutrient salts present in early spring. This interesting result is not yet fully explained, although it is suggested that the rushing of tides through the narrow channels over uneven bottoms results in a turbulence tending to keep the supply of nutrient salts evenly distributed through the water, the constant mixing hindering the plankton development since no warm surface layer can develop and the

dividing cells cannot remain in the photic zone long enough to permit prolonged growth. Thus the two factors — high nutrient salt content and instability of surface water — are conflicting. These together with the increase in the depth illumination sufficient for photosynthesis as the season advances may account for the delay of the beginning of diatom growth until May. From May to June is the first large maximum, and a second still larger occurs from mid-July to mid-August, corresponding with rise of temperature of the sea. The growth was never dominated by one species but rather by a group of two to five species. *Chaetoceros compressus, C. debilis, C. radians,* and *Skeletonema costatum* were dominant in the first maximum, *C. debilis, C. didymus,* and *Skeletonema costatum* in the second. In East Sound, representing long narrow bays, the annual period of productivity began in early March and continued through spring and summer with a maximum in June; there the diatom species were much the same as in the San Juan Channel but there was a marked succession of dominant genera and species. This difference in season is probably due to the long bays being little disturbed by strong tidal currents, the surface waters having an opportunity to increase in temperature, favouring the beginning of plant growth early in spring when the water contains ample nutrient salts.

*M. V. L.*

**J. D. Sømme.** "Animal Plankton of the Norwegian Coast Waters and the Open Sea. I. Production of *Calanus finmarchicus* (Gunner) and *Calanus hyperboreus* (Kroyer) in the Lofoten Area." Fiskeridir. Skr., Ser. Havunders. Vol. IV, No. 9. Bergen, 1934.

In this treatise the conclusions, which after a brief discussion are set out in the earlier pages, are considered more or less exhaustively from almost every bearing. These conclusions are, shortly, as follows: — In the Lofoten area *Calanus finmarchicus* and *C. hyperboreus,* mainly in the penultimate stage of development, spend the winter in the deep water of the fjords. In the early part of the year *C. finmarchicus* migrates to the surface shortly before reaching maturity and is carried outwards by the surface current of cold and less saline water derived from the shore area. Spawning takes place a little later when the species is widely distributed over the coastal banks, and is continued through several generations during the summer. *Calanus hyperboreus,* in contrast to this, reaches maturity before the end of winter but delays its upward migration till its single annual spawning period is imminent or actually in progress, with the result that the spawning area is restricted to the localities where depths suitable for the shelter of the species during the winter are present.

In working towards these conclusions the author has been led to explore many paths leading up to them. In order to distinguish between the young stages of the two species he has worked out anew the morphology of the various stages from the egg to the adult and has pointed out some omissions in Dr. Lebour's earlier descriptions of *C. finmarchicus.* It seems, however, an exaggeration to refer to these differences, as Mr. Sømme does, as many and great discrepancies. Some of the apparent differences are due to the use of a different terminology; for example, in the account of the swimming feet Mr. Sømme enumerates without distinction both the articulated spines and the non-articulated tooth-like projections while Dr. Lebour does not refer to the latter. These morphological researches did

not disclose any significant differences which would distinguish the younger stages of the two species but a series of careful measurements showed that, in the area investigated, size could be used as a distinguishing character. It is suggested in the paper that in future the nauplius and copepodite stages of the Copepoda should be designated successively I—XII instead of the more generally used notation of nauplii I—VI and copepodites I—VI, a proposal which may be logical but which does not seem to have any other advantage.

The last half of the paper is given up to showing how the tow-nettings taken at various times, mainly in the Lofoten area, have led to the conclusions outlined above. One point is still not clear in the account of the annual life cycle. There is no suggestion as to how or from what source the wintering stock is constituted, whether by the gathering together of the inhabitants of a large area into the deepest part of the area or by the survival *in situ* of a portion of the stock in the winter habitat.

The basic idea underlying the whole paper is the proposition that the summer or young stage distribution is traceable back each year to the area in which the breeding stock-to-be has spent the winter, and from this it follows that the extent of the distribution depends more on the distributing agency than on the suitability of the region occupied.

*G. P. F.*

**B. G. Bogorov.** "Seasonal Changes in Biomass of *Calanus finmarchicus*" in the Plymouth Area in 1930." Journ. Mar. Biol. Assoc. N. S., Vol. XIX, No. 2. Plymouth, 1934.

It is a great pity that neither the lengths nor the weights of the *Calanus* from the Plymouth area, which form the subject of this interesting paper, are directly comparable with those of *Calanus* from Loch Striven (J. M. B. A., Vol. XIX, p. 793.) Bogorov's lengths are measured from the front edge of the cephalothorax to the end of the caudal furcae, caudal setae being excluded; the median lengths for the Loch Striven *Calanus* are from measurements of the cephalothorax only. Bogorov's dry weights are those of formalin-preserved specimens dried over calcium chloride in a desiccator for two or three days; the Loch Striven dry weights are those of fresh specimens dried to a constant weight at 110° C. It is sincerely to be hoped that, in future, observers in different localities will employ identical methods, and the question is one on which a pronouncement from the International Council would be welcomed.

According to Orr (J. M. B. A., XIX, p. 260), lengths as determined by Bogorov are about 20 % greater than the cephalothorax measurements of the L. Striven material. Accepting this correction, but bearing in mind that Bogorov's measurements are of preserved specimens, comparisons of length between Plymouth and L. Striven *Calanus* are as follows: —

| | Autumn-Winter | | | Spring | | | Late Summer | | |
|---|---|---|---|---|---|---|---|---|---|
| | V | ♂ | ♀ | V | ♂ | ♀ | V | ♂ | ♀ |
| Plymouth[1]) | 2.72 | 3.00 | 2.96 | 3.07 | 3.57 | 3.57 | 2.87 | 3.26 | 3.28 |
| L. Striven | 2.54 | 2.81 | 2.83[2]) | 2.87 | 3.02 | 3.18[3]) | 2.72 | 2.76 | 2.74[4]) |

[1]) p. 594, Table IV.
[2]) Mean of 17. I. to 27. III.
[3]) Mean of 4. IV. to 29. V.
[4]) Mean of 28. VIII to 2. X.

In view of the difference in technique it is, unfortunately, impossible to compare the weights of the two populations.

Throughout this paper Bogorov uses the term "biomass" to connote the "quantity of substance in a living organism at a given moment." Biomass was determined by periodic measurements of raw (wet) and dry weights. Stage V and adults only are considered. The Plymouth material shows the same sudden and marked rise in weight in mid-April and the decline in the autumn as recorded for L. Striven. Whilst in L. Striven Stage V were, for the greater part of the year, heavier than either males or females, those from the Plymouth area were usually lighter. The wet weight of Stage V, however, was very considerably less, thus agreeing with the L. Striven results (l. c., p. 804).

Bogorov is able to recognize three well-defined biomass types, which he names the spring (May), the summer (June—September) and the autumn—winter (October—April) types. Further, he believes that these types arise from three periods of breeding.

These three types are recognizable also by their size, the largest being those of the spring, the shortest those of the autumn—winter period. At first sight it would seem that the autumn—winter stock should be the biggest, since it is known that the length of *Calanus* varies inversely with temperature. Bogorov points out, however, that the spring *Calanus* are hatched and developed in the cold winter water of 8—9° C., whilst the autumn—winter stock were developed in the warm water characteristic of the end of autumn (15—16° C). In other words, the size attained and the temperature conditions prevailing during development are inversely proportional.

The author makes the interesting observation that the greatest biomass occurs at a time when *Calanus* are most numerous, and concludes that "conditions favourable for the rise in biomass, are at the same time optimal ones for the development of great numbers of individuals."

He includes a brief comparison of the *Calanus*-type found in the Barents Sea with that from the Channel, and this section will appeal to those interested in the problem of local races.

*A. C. G.*

**F. S. Russell.** "The Vertical Distribution of Marine Macroplankton XII. Some Observations on the Vertical Distribution of *Calanus finmarchicus* in Relation to Light Intensity." Journ. Mar. Biol. Assoc N. S., Vol. XIX, No. 2. Plymouth, 1934.

This paper contains two departures from this author's previous practice and enables a more rigid test to be applied to his theory of optimum illumination than has previously been the case. The new features are, firstly, measurement of light intensities beneath the sea surface simultaneously with townettings and, secondly, the use of a number of nets attached at different levels to one warp, enabling the various depths to be sampled at one and the same time.

The present account, which relates to adults of *C. finmarchicus* only, lends considerable support to the author's views on the importance of the degree of illumination in vertical distribution, but tends once more to indicate the complexity of the problem.

Russell's earlier work showed that differences in day-time behaviour of *C. finmarchicus* were to be expected during different seasons of the year, but that such differences were to be related to variations in the size of the

individuals composing the populations sampled. This point comes out clearly in the present experiment. He had also shown that females were tolerant of higher light intensity than were males; this, too, is confirmed. Further, when on July 21st two series of observations were made, the second, in the late afternoon, showed adult female *Calanus* to be much more markedly concentrated at the surface when the illumination was less than 24.7 than had been the case at 2.30 p. m. when the illumination was in excess of 80.8 thousands of metre-candles. Again, on August 12th, when once more two series were taken, the maximum number of female *Calanus* at 11.0 a. m. occurred at a depth of 7.5 metres, whilst in the afternoon there were more individuals at 13.8 than at 7.0 metres *but* the vertical illuminations at a depth of 0.5 metres were 24.4 and 31.6 thousands of metre-candles respectively.

Despite general confirmation of his theory the author is compelled to state, p. 579, that "it is difficult to decide on the optimum conditions [of illumination] except within wide limits." This may be illustrated by the following figures. On July 21st, in the early afternoon, female *Calanus* were living right up to the surface; the next day the surface was avoided at 11.45 a. m. and the greatest numbers occurred at a depth of 8.1 metres. The conditions of illumination, however, were approximately the same, namely 80.8 and 72.8 thousands of metre-candles at a depth of 0.5 metres.

Russell points out that such discrepancies may be the result either of the animals' increased adaptation to a higher light intensity throughout a day, or to their inability to keep accurately to their optima on days when the degree of illumination is constantly changing.

The actual measurements of light intensity were the work of Dr. W. R. G. Atkins and those who may wish to study this aspect in greater detail should consult the original paper (Phil. Trans. Roy. Soc. London, Ser. B, Vol. 222, 1933).

Russell points out that this experiment was in the nature of a preliminary one, and further communications on the same lines will be awaited with interest.

*A. C. G.*

**S. M. Marshall, A. G. Nicholls** and **A. P. Orr.** "On the Biology of *Calanus finmarchicus.* V. Seasonal Distribution, Size, Weight and Chemical Composition in Loch Striven in 1933, and their Relation to the Phytoplankton." Journ. Mar. Biol. Assoc. N. S., Vol. XIX, No. 2, Plymouth, 1934.

It is impossible in a short review to give this account the consideration it merits. It is a paper which should most certainly be read in the original by all planktologists. The authors deserve great credit for having given so detailed an account of the biology of *Calanus finmarchicus* but perhaps even greater for having published, in May 1934, data relating to the year 1933.

The aspects dealt with include the following:— seasonal distribution of all stages in the life history from egg to adult, recognition of the times of breeding and duration of various broods, records of length of all copepodite stages and of dry weight, protein and fat content for Stages V and VI. To this list may be added records of the phytoplankton, notes on vertical distribution, observations on the seasons at which females were found to be carrying spermatophores and on the ripeness of the ovaries, and, lastly,

an interesting account of the parasites. It is true that the data are derived from collections at one station only, but five hauls were taken in quick succession to ensure a truly representative sample.

This, then, is the scope of the paper and it is unfortunately possible only to comment briefly on some of the many points which have interested the writer of this review.

Fig. 2, p. 799, showing that after the end of May over 90 % of all stages of *Calanus* occurred below 10 metres, whereas prior to this time almost all were above 10 metres, is particularly striking.

It is a pity that considerations of space prevented the authors from giving length data other than median length, an expression which is not readily susceptible to further statistical treatment. Length-frequency tables of the type given by Bogorov, J. M. B. A., Vol. XIX, p. 612, would surely have peen permissible in view of their interest to other workers. In general, there was a gradual decrease in size throughout the summer, but the size-temperature relationship is complicated by the fact that individuals from eggs produced at the beginning are larger than those from eggs produced at the end of a period of breeding.

The data for dry weight provide much that is interesting. They refer to individuals in Stage V and to males and females; in all of these categories there was a sudden and very marked rise in dry weight coincident with the appearance of the first brood in mid-April. One surprising fact is that Stage V, whilst being on the whole shorter than either males or females, have, for the greater part of the year, a considerably greater dry weight. Some determinations of wet weight, however, showed *Calanus* in Stage V to contain a smaller percentage of water than the adults and thus in the living state the latter are heavier than Stage V.

It is perhaps impertinent to suggest to these workers that they should add more routine observations to the considerable array already standard, but data on the percentage of *Calanus* feeding would add weight to their phytoplankton investigations.

Data on chemical composition relate similarly to Stage V and adults. The actual content and percentage of fat were greatest in Stage V. Increase in fat is to be related to broods and probably to periods of abundance of diatoms. The great increase in weight in the spring is due more to fat than to protein.

The authors make the interesting observation that parasitized specimens are often recognizable by their colour. Those with cestode, trematode and dinoflagellate parasites, for instance, are coloured red. The other parasites such as an isopod of the genus *Microniscus*, nematodes and gregarines do not affect the colour. Infection was heaviest in the autumn—winter stock.

In conclusion, it is hoped that this team will continue their researches and perhaps utilize their detailed information concerning the life history of Loch Striven *Calanus* in a study of the animals' vertical distribution.

*A. C. G.*

**A. P. Orr.** "On the Biology of *Calanus finmarchicus*. Part IV. Seasonal Changes in the Weight and Chemical Composition in Loch Fyne." Journ. Mar. Biol. Assoc. N. S., Vol. XIX, No. 2. Plymouth, 1934.

This paper belongs to the series dealing with the life history of the *Calanus* of the Clyde sea area, of which Loch Fyne is a semi-enclosed arm. The data are derived from some 14 collections spread over a year

and relate to adult and Stage V *Calanus*. Only the latter were present in sufficient quantity to enable estimations to be made at all regularly. The data for males are for two months only, whilst the eight sets of determinations in the case of females cover four months.

The dry weight of all classes showed considerable seasonal variation, individuals in Stage V, for instance, being three times as heavy in December as in May. On this account the author has expressed the fat and protein contents as percentages of the dry weight.

Figures for fat and protein content are based in most cases on duplicate measurements, two for each sample of plankton. The results of the parallel estimations should presumably differ from each other by only small amounts due to the experimental errors inherent in the method. On two occasions, however, the differences between pairs of protein estimations in Stage V Calanus were fairly considerable, e. g. 32 % and 44 % on 17.XI.31 and 30 % and 44 % on 30.X.32. That such large discrepancies may occur raises the important question as to the validity of the method in the determination of seasonal variation in protein content.

In order to test this point the variance of the observations given in Table III, p. 629, has been analysed. There are only eight pairs of estimations, scarcely enough on which to base any very definite conclusion, but there exist a further twenty pairs of protein estimations for Stage V *Calanus* in the paper by Miss Marshall, Dr. Nicholls and Mr. Orr, J. M. B. A., XIX, 2, Table V, p. 826. The variance of these data has accordingly been subjected to analysis by the same method, namely that of Fisher *(Statistical Methods for Research Workers,* London, 1930, p. 216).

It would appear, in the latter case, that the seasonal variations in protein content are probably, but not certainly, significant. Such variation as is shown would occur in something between 1 % and 20 % of random samples from a population in which there was no seasonal variation, but nearer 20 % than 1 %. In the case of the eight pairs of estimations, taken from the paper under review, the higher values recorded have no significance.

It should be pointed out that Mr. Orr does not claim to have demonstrated seasonal variation in protein content; at the same time it should be made clear that the variations disclosed by Fig. 3, p. 622, are as yet to be interpreted with caution.

A section on the food value of *Calanus* in Loch Fyne is included. The weights of fat and protein have been calculated from Nicholls's data on the seasonal numerical variations in the area (J. M. B. A., XIX, 1, 1933).

*A. C. G.*

**M. W. Smith.** "Physical and Biological Conditions in Heavily Fertilized Water." Journ. Biol. Board Canada. Vol. 1, No. 1, pp. 67—93. Toronto, 1934.

The material for this paper is derived from the study of conditions in a small concrete pond to which 1000 pounds of cow manure had been added. In so far as one is entitled to compare such a specialized environment with more natural ones, the results are very much what one would expect to find, except that the fluctuations in chemical and physical factors are considerably wider. The recorded rise in dissolved oxygen content and in the pH value coincident upon times of great phytoplankton production,

effects of decomposition, pH and temperature gradients, and periodic "overturnings" call for no special comment.

The object of manuring a pond is presumably to increase the amount of plankton and, as the author points out, "the ideal is that the good effects should more than counterbalance the bad effects ..." With only one experimental pond under observation it is hard to see how this particular aspect of the problem has been tackled. There was, of course, a considerable production both of zoo- and phytoplankton, but in the absence of any control it is impossible to decide whether 1000 pounds of cow manure produces the best results.

The author states that this was in the nature of preliminary work and that "more restricted and controlled experiments" were contemplated. From the point of view of the fish culturist, work of this kind is desirable, and it is to be hoped that future experiments will provide data on the optimum quantity of manure which should be added to produce the maximum amount of crustacean fish food.

*A. C. G.*

**R. Southern.** "Reports from the Limnological Laboratory. III. — The Food and Growth of Brown Trout from Lough Derg and the River Shannon." Proc. Roy. Irish Acad. Vol. XLII, Sect. B, No. 6. Dublin, 1935.

In spite of the importance of the brown trout (*Salmo trutta* L.) as an edible and sporting fish we know far less of its biology than we do of its relatives the sea trout and salmon. In this paper Mr. Southern sets out the results of his studies on the brown trout in the R. Shannon basin, made over a period of fifteen years, mainly as a side line to other work.

In all, 293 fish were examined for age determination; of these 121 were taken at various points in the R. Shannon, 96 in Lough Derg, and 53 in Lough Atorick; the remainder were taken from tributaries of the Shannon. The data recorded include the age, sex, growth-rate, reproductive history (so far as this can be deduced from the appearance of the gonads and the scales) and the condition factor. The author points out the difficulties of reading and interpretation of the scales of brown trout which make them less reliable guides to the life history than they are in the case of the salmon. For example, no trout from L. Atorick bore a spawning mark on its scales, even though it could be recognised from the condition of the gonads as a spent fish. The scales of trout from L. Derg and the R. Shannon, on the other hand, showed erosion after spawning.

Trout from L. Derg and the R. Shannon show very similar life histories; growth is rapid and the fish comparatively long lived, so that large trout are common. The greatest increase in length occurs in the 2nd, 3rd, and 4th years, whilst the greatest increase in weight is made in the 4th, 5th, and 6th years. Fish in these waters usually spawn for the first time when they are 4 years old and thereafter spawn annually. The ripening of the gonads reduces the growth-rate and hence it is found that the exceptionally large trout are those which have matured at a relatively advanced age.

Trout from L. Atorick grow very much more slowly than those discussed above and are much shorter lived. Hence the fish are small, none over 6 oz. in weight having been captured. Incidentally the heaviest trout recorded from L. Derg weighed 30 lb. The disparity in the rate of growth increases

with the age of the fish. On the average at the end of the first year a L. Atorick trout is 51 per cent. of the weight of a L. Derg trout of the same age, whilst at the end of the 4th year the ratio is 12 per cent. L. Atorick trout make the greatest increase in length in their 2nd year and in weight in their 3rd year, and on the average they spawn for the first time at three years old, that is, a year younger than L. Derg and R. Shannon fish.

This tremendous variation in the growth-rate of members of the same species is correlated with the difference in the waters of the two areas. L. Derg and the R. Shannon lie on the great limestone plain of central Ireland and their waters are alkaline, whilst L. Atorick, though connected to the Shannon basin, lies in an area of Old Red Sandstone and its waters are acid. The cause of this correlation is, however, not yet clear. One would assume that as alkaline waters usually support a far more abundant fauna than do acid waters, that it would be a matter of food supply and in the second part of this paper this question is discussed.

The data were obtained by the examination of the stomach contents of 97 trout from L. Derg, 21 from the R. Shannon and of 22 from L. Atorick. The principal food of L. Derg trout was perch fry, mayflies (adults and larvae), *Asellus* and Cladocera of the plankton and there appeared to be a seasonal variation in the nature of the food. L. Atorick trout, on the other hand, fed mainly on insect larvae, winged insects (a large proportion of them being of terrestrial origin) and on Mollusca. In none of them was there found any Cladocera although they are present in the plankton of the lake. On the basis of this material Mr. Southern does not consider that the difference in the food supply accounts for the difference in growth-rate. He points out that there was no evidence of any shortage of food in L. Atorick and that the trout do not appear to use the abundant supply provided by the Cladocera of the plankton.

Mr. Southern is inclined to seek the explanation of the difference in growth-rate in some chemical constituent of the water but more evidence is needed before the food supply theory can be discarded entirely.

The brown trout has suffered as much as any fish at the hands of the quasi-scientific speculator and it is most refreshing to find that this paper deals with the collection of and deductions from, facts.

*F. T. K. Pentelow.*

**M. S. Idelson.** "Materials for the quantitative evaluation of the bottom fauna of the Barents, White and Kara Seas. No. 7. Distribution of the benthos biomass in the Southern Barents Sea. The influence of different factors on the density of the sea bottom population." Trans. Oceanogr. Inst. Vol. III, No. 4. Moscow, 1934.

The first half of this paper is in Russian, but the second half of about 10 pages is a more or less complete English translation. In the first place the author reviews the literature dealing with the factors which determine the density of the bottom fauna, and then proceeds to discuss in greater detail which factors affect the distribution of the bottom fauna in the Barents Sea. The measurement used is that of the weight of animals per square metre (biomass). Only samples taken on mud or sandy mud are included.

The biomass decreases with the depth. In the Barents Sea, for example,

in depths from 0 to 100 m. the biomass was 301 gm. per sq. m., while for depths from 300 to 400 m. it was only 48 gm. per sq. m., except in the Novaya Zembla Gully with depths from 160 to 185 m. where it was almost equal to that of the shallowest parts. This decrease of the biomass with depth is possibly to be correlated with the decrease in organic matter.

In the Barents Sea the temperature also plays a great part, the biomass being very distinctly greater where the temperature is below zero (—2 to —0° C.) than where the temperature is above zero (+0 to +4).

These two correlations of the biomass with depth and temperature seem to supply adequate reasons for most of the variations in the density of the bottom fauna of the Barents Sea.

The lamellibranchs, echinoderms and polychaetes constitute the chief groups of the bottom fauna in most areas, although here and there others are important. For example the gephyrean *Phascolosoma margaritaceum* is of great importance in the muddy soils of Kanin and Petchora, while the Kildin Bank yields enormous masses of sponges.

The greatest biomass of lamellibranchs occurs in depths of less than 100 m. (200 gm. per sq. m., making 67 % of the total biomass), but after that depth it falls rapidly. At 100 to 200 m. it is only 88 gm. per sq. m., or 52 % of the biomass. At 200 to 300 m. and 300 to 400 m. the weights are 15 gm. and 5.5 gm. and the percentages 16 % and 11 %, respectively.

The echinoderms present quite a different picture. Down to 100 m. their weight per sq. m. is 7.4 gm., making only 2 % of the total biomass. At depths of 100 to 200 m., 200 to 300 m., and 300 to 400 m. the weights are all very similar, lying between 20 and 30 gm., but owing to the decrease of the biomass the percentage rises from 15 % to 44 %.

The greatest weight of polychaetes occurs in depths of less than 100 m. (42 gm. with a percentage of 13.7 %). From 100 to 400 m. the weight remains fairly constant, being from 16 to 22 gm. and giving percentages from 10 to 23.5 %.

The author notes that where lamellibranchs are abundant echinoderms are scarce, and *vice versa*. His observations on the density of the lamellibranchs and echinoderms in relation to depth and to one another are in good accord with the results of recent work in the North Sea.

*A.C.S.*

**A. Bückmann.** "Untersuchungen über die Naturgeschichte der Seezunge, die Seezungenbevölkerung und den Seezungenfang in der Nordsee." Ber. deutsch. wiss. Komm. f. Meeresf. N.F., Bd. VII, H. 2. Leipzig, 1934.

In this useful paper the author delivers a meticulously composed and practical manual on the North Sea sole, which ought to be highly appreciated by fishery biologists as a sound basis for future investigations. The common sole is a most important species, whose value comes directly after those of the principal demersal fish (cod, haddock, hake and plaice) and is in the southern North Sea second only to that of the plaice. To the German colleagues who for a series of years devoted their attention to this somewhat neglected fish our thanks are due for the enlargement of its biological knowledge.

After a rapid glance at former literature regarding the subject and a discussion of method of investigation, both in inshore waters and on the

high sea, the author deals with the age determination (by means of the scales). In the German Waddensee the final length of the 0-group is about 8 cm.; in the next year the young fishes, at least the better grown, move out to deeper water, and the I-group reaches a length of about 18 cm. During the third year of life the sole finally leaves inshore waters and inhabits moderate depths; at the end of this year maturity begins, especially with the males, at a length of 22—23 cm. Female soles (whose rate of growth is quicker than that of males) partly reach maturity at a length of 24 cm.; at 27 cm. length 50 % of them are still immature. Spawning occurs in May—June in shallow coastal waters, and spent soles retire to depths of 15/40 m. in July, to resort to depths of more than 25 m. from September onwards. It is a well-known fact that adult soles keep to the 40 m. depth-line during the winter months.

The next chapter is firstly devoted to the effects of the close time during the war in the earlier 'twenties; it is a striking fact that since 1928 large soles of more than 35 cm. length have become increasingly rare, much more so than in pre-war years. Furthermore we get an instructive survey of fluctuations of brood production: a good series of them occurred in 1924—1926, after which we get two poor years. The year-classes of 1929—1932 again are outstanding, especially 1930. Of course the disastrous effect of the first months of 1929 on the adult sole population of the German Bight, well remembered by North Sea fishermen, is also mentioned; it is, nevertheless, remarkable that that year turned out to yield a good brood.

The discussion on statistics of English, German and Dutch catches, which constitutes the third chapter, is very interesting. The landings of the various market categories in consecutive years illustrate the fluctuations and the unforeseen vicissitudes of the sole population in the southern North Sea.

Altogether an excellent piece of research, concluded by a concise summary, in which suggestions of size limits (24 cm. in Germany has been proposed) and its prospective effects, together with considerations on gaps in our present knowledge, form a most valuable part. Especially in Holland, in which country both the absolute landings of soles (more than thrice that of pre-war years) and the catch per fishing day are larger even than those of England in the last few years, high tribute ought to be paid to Bückmann's painstaking work.

*J. J. T.*

**W. C. Hodgson.** "The Natural History of the Herring in the Southern North Sea." The Buckland Lectures for 1933. Edward Arnold, London, 1934.

This handy booklet treats, in three lectures delivered in 1933 by the well-known English authority, both from the scientific point of view and from that of the industry, of the herrings in the southern North Sea and the eastern part of the English Channel.

The author starts with a general discussion of the methods of age determination by means of the scales, and a sketch of the biological and ecological factors in the life cycle of the herring.

In the second chapter the age distribution in the East Anglian herring shoals in post-war years (1923—1932) is dealt with and, of course, the largely fluctuating abundance of consecutive year-classes is amply discussed. These fluctuations are neatly expressed in the yearly abundance of year-classes, but, as regards the young fish (3 or 4 years old) it is to be borne

in mind that these as a rule constitute a kind of vanguard and make an early appearance in the shoals. Even daily fluctuations are noted, and in this respect the influence of the full moon and the (sometimes deleterious) effect of plankton, in which connexion the influence of *Calanus* on the one hand and phytoplankton on the other (the presence of which may be revealed by *Hardy*'s plankton indicator), are brought to the notice of the practical fisherman in a clear and comprehensive way. As set-backs to the East Anglian fishery the badly starting operations, interfered with by the presence of voluminous quantities of phytoplankton (1921: *Rhizosolenia;* 1927: *Phaeocystis;* 1933: *Rhizosolenia* again, coupled with *Biddulphia)* are worth being recorded somewhat regretfully, though gratefully, by the naturalist.

The third, and last, chapter is perhaps the most interesting, for here the writer, speaking with his well-earned authority of personal research, proceeds to the question of forecasts. This difficult problem is dealt with in an admirable way, and the wealth of preparative knowledge, patiently collected during a series of years, about age determinations, rate of mortality of year-classes etc., forming the starting points of predictions about the quality of the herrings in the season to come, is put before the layman, who cannot fail to be impressed by the enormous amount of research needed to get the necessary working theses.

This chapter closes with an interesting discussion on the question whether the alleged larger quantities of "small matties" of recent years, compared with pre-war times, are due either to different selection on the part of the curers, to influence of smaller-meshed drift nets used, or to different composition of the herring shoals. The solution of this problem is to be sought for in the first two suppositions named. Herrings are apparently now being selected in a way different from that of pre-war custom, at least by "trade markers", so that "small matties" nowadays, up to as much as 50 and even 69 %, contain fishes of more than 9¼ inches (= about 23.5 cm.), viz., the minimum length of this category laid down in the Herring Branding Act (1913). Furthermore it was shown by experiments that nets of 35 rows per yard catch herrings of 21—23 cm. length, which are practically absent from catches made by wider-meshed nets (33 or 31 rows per yard). Inquiries about the character of nets used before and after the war gave contradictory results, but on the whole it seemed that the size of mesh has decreased since the years after 1914. The meshes of present-day commercial nets go down to 36, 37 or even 38 rows per yard. At North Shields they decrease even to 42 and 48 rows per yard .... So the alleged larger quantities of "small matties" are due to a change in methods and not to one of composition of herring shoals.

We have dwelt more largely on this particular point of the industry, in order to demonstrate the careful way in which various problems of the herring fishery, as far as fishing and curing are concerned, are taken into consideration. Dr. Hodgson has bestowed valuable information on a larger audience than could be reached by his lectures, however well attended, and, though the bulk of the booklet may be generally known to fishery biologists, this *vade-mecum* is to them, as well as to the practical fisherman, a treasure which cannot be too highly appreciated. The low price of 3/6 can hardly be an objection to its purchase.

*J. J. T.*

**W. F. Thompson** and **F. H. Bell.** "Biological Statistics of the Pacific Halibut Fishery. (2) Effect of Changes in Intensity upon Total Yield and Yield per Unit of Gear." Rep. Internat. Fish. Comm. No. 8. Seattle, Wash., 1934.

A very brief notice of this paper is sufficient to show its importance. The authors show how it was possible to foresee the effect on the fishery of certain restrictions. The restrictions were made. The expected effect was shown in the fishery statistics. The same theory is found to fit closely to the facts in two other outstanding examples from the statistics. Detailed description of the paper is unnecessary here, for it is obviously one which everyone interested will wish to read in the original.

If one should criticize a paper which so notably advances the theory of fishery statistics, one would be inclined to say that, despite the agreement between theory and experience cited, the theory as given is still too far removed from reality to be very practicable. Here is truly material for another paper, which the reviewer is preparing. One example will, however, serve as sufficient warning to readers. From p. 10: "But it is equally obvious that where the growth-rate is slow, less than the mortality from natural causes, the greatest total yield from a given number of incoming young is produced by an intense fishery ...." If the growth-rate were *constantly* less than the mortality from natural causes, even for adults, the stock would not exist, for its weight would progressively decrease to zero. There would therefore be no incoming young and no fishery. There is needed therefore some treatment of the variation in the postulate as to the ratio of growth-rate and natural mortality.

No foreign literature is cited in this paper. Without wishing in any way to belittle the very great achievement of the authors, the reviewer is not confident that use has been made of earlier advances along these lines, especially E. S. Russell's paper in this journal, Vol. VI, p. 3, 1931, and the theories of Malthus and of Pearl, cited in the papers of Hjort and his school in *Hvalrådets Skrifter* 7, 1933.

*M. G.*

**Chr. Hessle** och **S. Vallin.** "Undersökningar över plankton och dess växlingar i Östersjön under åren 1925—1927." ("Investigations of plankton and its fluctuations in the Baltic during the years 1925—1927."). Svenska Hydrogr.-Biolog. Komm. Skr. N. S. Biologi, Bd. 1, Nr. 5. Stockholm, 1934.

The purpose of the investigations described was to find out whether the migrations of the herrings into the coastal basins of the Baltic were due to a difference between the plankton production of the open Baltic and of these basins. Furthermore, it was of interest to study the question whether there was a connexion in other respects between the fluctuations of the plankton production and the occurrence of the Baltic herring.

A very large number of plankton samples was collected in the area extending from the Bornholm Basin to Botten Bay (the innermost part of the Gulf of Bothnia). Several instruments were used, viz. a 0.5 m. closing net, a 1 m. vertical net, a sledge net, which was dredged along the bottom on runners, and a 2 m. ring-trawl. In connexion with the collection of plankton samples hydrographical observations were made.

As regards the investigations of the phytoplankton no quantitative determinations have been made, but only the relative frequency of the different species has been estimated and stated by means of the usual symbols. For the central part of the Middle Baltic there is in summer and autumn a very rich production of schizophyceans, especially *Aphanizomenon,* but it decreases towards the north and is comparatively scarce in Botton Bay. Among the diatoms the species *Chaetoceras balticum* and *C. wighami* are, from a quantitative point of view, the most important. A survey of the occurrence of the principal phytoplankton species during different seasons and within the different central basins is given, but of the frequency and distribution of the different zooplankton forms the paper gives a more complete account, which contains a number of interesting results.

The chief groups, at least in number of individuals, of the coarser zooplankton of the Baltic are rotatorians, cladocerans and copepods, but as food animals for herring and for young stages of other fishes the copepods are probably the most important zooplankton group of the Baltic. Furthermore other forms as, for instance, amphipods *(Pontoporeia)* and schizopods *(Mysis)* are of great importance in different parts of the area investigated. A special and comprehensive chapter of the report contains an account of the findings concerning the horizontal and vertical distribution of the different zooplankton forms, their annual fluctuations of frequency, and the part the more important groups and species play in the plankton production. Of special interest is a series of tables and graphs giving the number of individuals per $m.^3$ of the more important species at different depths during the various months at some more regularly investigated stations. In connexion with the treatment of the schizopods a short survey is given of some investigations concerning the stomach contents of the different *Mysis* species in the Baltic.

After the more special parts of the report follow some chapters giving an account of the horizontal and vertical distribution of the chief plankton species of the area investigated and a more general survey of the quantitative and qualitative composition of the plankton in the central basins of the Baltic as well as in the coastal basins.

As the hydrographical conditions in several respects were different during the years in which the investigations were carried out the authors have found that the fluctuations of the plankton quantity in the Middle Baltic are influenced to a very high degree by the fluctuations of the hydrographical conditions. They are, however, of the opinion that the same hydrographical factors may have different effects on the composition of the plankton within the central open parts of the Middle Baltic and in the coastal basins of the area investigated.

In a final chapter the relation between the migration of the herring into certain coastal basins during autumn and the quantity of plankton is discussed. It is found that the migration is not caused by the differences between the plankton quantities in these basins and the areas outside them, but the details given by the authors seem to show that the comparatively strong stocks of stationary fjord-herrings which occur in certain isolated deep fjords are dependent on the abundance of plankton in these fjords. With regard to the migrations of the herring it would have been of interest if investigations on the nourishment and stomach contents of the herring from various areas and at different times of the year had been carried out in connexion with the plankton investigations, but in this direction the present paper gives no information. On the other hand it seems probable

that the size of the stock of herring in the different areas of the Baltic is related to the production of the plankton in the same areas.

The publication under review contains a great number of data concerning the distribution and the abundance of the various plankton species in the Baltic and is therefore of the greatest interest for any one who is working with problems in connexion with the plankton of this area.

*P. Jespersen.*

**P. Jespersen.** "The Godthaab Expedition 1928. Copepoda." Komm. Videnskab. Unders. i Grønland. Medd. om Grønland. Bd. 79, Nr. 10. København, 1934.

During the Danish Godthaab Expedition to the west coast of Greenland numerous collections of plankton were made both at or near the surface and in deeper water to a depth of approximately 2000 metres. The Copepoda of these collections have been worked out by the author and are here reported on, special attention being given to the three most abundant species *Calanus finmarchicus, Calanus hyperboreus* and *Metridia longa.*

*Calanus finmarchicus,* the seasonal variation in size of which has recently attracted the attention of a number of workers, was here found to fall into two clearly marked size-groups, corresponding in the adult to average total lengths of 5.2 and 3.6 mm., the larger sized group occurring most abundantly in the extreme northerly stations and on those close to the western side on the more southern part of the area. A clear correlation was noted between the water temperature and the proportional numbers of the two groups, the smaller individuals forming the highest proportion of the hauls where the temperature was highest. *Calanus hyperboreus,* on the contrary, though taken with a wide range of sizes, showed only a single size-group, due no doubt to its single breeding season.

The general collections furnish a noteworthy addition to our knowledge of the distribution of North Atlantic Copepoda, the most striking fact being the capture of a large number of species which are characteristic of the deep water of the North Atlantic. Out of the 108 oceanic species found to the west of Greenland the number of distinctly arctic or boreal forms did not amount to more than about ten, while as many as eighty-five were normal inhabitants of the deep water of the temperate Atlantic.

It is at first sight somewhat surprising to find the deep water fauna of the neighbourhood of the Azores extending up to the Davis Strait until it is realized that this water stretches uninterruptedly with little change of temperature as far as the submarine ridge underlying the strait.

*G. P. F.*

**E. Steemann Nielsen.** "Untersuchungen über die Verbreitung, Biologie und Variation der Ceratien im Südlichen Stillen Ozean." Dana-Rep. No. 4. Copenhagen, 1934.

Steemann Nielsen stellt nach dem "Dana" Material im Stillen Ozean 60 Ceratienarten fest, die meist in Schliessnetzserien aus 200—100, 100—50 und 50—0 m. Tiefe gefangen wurden. Das Fahrtgebiet der "Dana" zwischen Panama und Australien—Neuseeland lässt sich, wennschon etwas

künstlich, in 7 Untergebiete einteilen, die hauptsächlich durch ihren eutrophen oder oligotrophen Charakter unterschieden sind. Zwei Hauptgebiete umfassen den Südäquatorialstrom, ein östliches eutrophes und ein westliches oligotrophes. Bei Neuseeland liegt ein temperiertes oligotrophes, südlich davon ein eutrophes Gebiet. Eutrophen Charakter haben auch die kleinen neritischen Gebiete bei Panama, bei der Nordinsel von Neuseeland und beim grossen Barrierriff, doch ist dies letzte nährsalzarm. Die *horizontale Verbreitung* der Ceratien entspricht nach Artenzahl und Artenauswahl diesen Gebieten. Als Faktor der Verbreitung spielt in wärmerem Wasser die Temperatur keine Rolle, doch muss die "Vorzeit" (Vorgeschichte) des Oberflächenwassers mehr als die Jahresschwankung der Temperatur bei der Beurteilung dieser Frage berücksichtigt werden (Vgl. dazu L o h m a n n, Int. Rev. Hydrob. Bd. 5, S. 206). Auch Salzgehalt und Nährsalzgehalt haben keine massgebende Bedeutung. Der Planktongehalt des Wassers aber hat einen grossen Einfluss, wenn auch nur sekundär. Denn in planktonreichen Gebieten findet ein Aufsummieren von Abbauprodukten des Stoffwechsels statt, die auf manche Arten vergiftend wirken. Auch die Meeresströmungen sind naturgemäss bedeutsam. Die *vertikale Verteilung* lässt eine ausgeprägte Schattenflora erkennen, deren Arten sich in tieferem, nährsalzreicherem Wasser bei wenig Konkurrenz durch extrem breiten, flachgedrückten, chromatophorenreichen Körper dem Lichtmangel angepasst haben. Sie leben, wie tabellarisch deutlich nachgewiesen wird, in planktonarmem Wasser tiefer als in planktonreichem, d. h. schattigerem. Die *Variation* der Ceratien wurde durch Messungen (Totallänge, Transdiameter, Antapikallänge) an häufigeren Arten untersucht. Die Tabellen zeigen deutlich einen wohl direkten Einfluss der Temperatur. In wärmerem Wasser sind die Zellen kleiner als in kälterem, was wohl keine Anpassungsbedeutung hat. Auf neritisches Wasser reagieren sie durch Vergrösserung, wohl wieder unter dem Einfluss aufsummierter Stoffwechselprodukte des Planktons, während dessen Menge unmittelbar ebensowenig wie der Nährsalzgehalt und der Salzgehalt wirksam ist. — Die Ceratienbevölkerung zeigt erstaunlich gute Übereinstimmung mit derjenigen des Südatlantischen Ozeans.

*E. H.*

**H. F. Prytherch.** "The Role of Copper in the Setting, Metamorphosis, and Distribution of the American Oyster, *Ostrea virginica*." Ecol. Monogr. Vol. 4, No. 1. Durham, N. C., 1934.

This paper constitutes an important addition to our knowledge of the life history of the American Oyster *(Ostrea virginica)*. The larvae of *Ostrea virginica* had been previously described by S t a f f o r d, but in this account certain structures, of special importance in the process of setting, are described in greater detail. There is a great development of the foot a short time before settlement, and with it the development of a byssus gland. This organ is embedded deeply in the body of the larva and opens by two ducts on the surface of the foot. The fully developed larva also possesses a pair of bluish-green pigment spots, the presence of which was taken as a criterion of full development in the larva. It was found that the structure and functions of various parts in the larva could be studied with ease in living examples immobilized by fixing one shell to a slide with a film of transparent glue. The author in describing the pigment spots refers to the fact that these have frequently been described as eyes, although no phototrophic response could be demonstrated. It is remarkable that in the European oyster *(Ostrea*

*edulis)*, although workers at Heligoland have described and figured definite eyes possessing a lens, yet no phototrophic response can be demonstrated in this species.

When about to settle the larva swims about until it comes in contact with a suitable surface for attachment, when the velum is retracted, the foot protruded, and the larva begins to crawl. During this phase a sticky thread of byssus is continually being secreted and forms a clearly marked trail showing the path taken by the larva. The crawling becomes slower and finally stops, the foot becoming short and stout and holding the larva down while the last drops of byssus secretion are forced out of the gland. At the same time the left valve of the shell is held firmly in the cement, which hardens within a few minutes. The foot is then withdrawn and setting is complete.

The preliminary investigation of the environmental factors governing the intensity of setting in different areas revealed that the lowering of salinity by river discharge had an important effect. In Milford Harbor, Connecticut, the greatest intensity of setting occurred at about low water when the salinity was approximately halved. In experiments in the laboratory, however, setting was not obtained in sea water diluted with distilled water, whereas dilution with river water was immediately effective in stimulating setting. An accidental contamination of distilled water with copper revealed that this element had the property of initiating the setting reaction in fully developed larvae. It was found also that very high or very low salinities increased the time occupied during the setting process, the effect being manifested in the physical condition of the byssus secretion, the viscosity, and consequently the ease of discharge, being adversely affected at both high and low salinities. Between salinities of 9—29 per mille the byssus secretion was normal.

Following the discovery that copper would initiate the setting reaction, an intensive investigation of all other likely chemical and physical factors was made, without discovering any factor which had the slightest stimulative effect on the fully developed larva. The same larvae could be induced to settle immediately by stimulation with minute traces of copper. It was found that, in order to have a stimulating effect on setting, copper had to be present to the extent of 0·05 to 0·6 mg./litre. At concentrations greater than 0·6 mg./litre the larvae received a lethal dose if exposed for any length of time. On the other hand concentrations of less than 0·05 mg./litre were ineffective in producing settlement. It is concluded that copper is extracted from the water by the larva in the form of a suspended colloidal copper salt. In the laboratory copper prepared as colloidal copper oxychloride was most readily ingested by the larva.

In the transformation of the larva into spat several changes occur in the structure of the oyster. The most striking of these are the disappearance of the pigment spots, the development of the posterior adductor as the chief shell muscle, and the appearance of leucocytes in the blood-stream. Following numerous careful experiments in the laboratory the conclusion was reached that a further ingestion of copper was necessary before metamorphosis could be initiated. After metamorphosis copper is non-essential. The concentration of copper producing metamorphosis varied from 0·1 to 0·5 mg./litre.

In the larva the pigment spots are described as consisting of a mass of densely packed cells containing green coloured granules, and enclosed in an endothelial sac. It is unfortunate that no detailed figure is given. It is concluded that the pigment spots break up and the cells are absorbed into the blood-stream, where their form and behaviour resembles that of leucocytes. It is suggested that the copper is combined in the blood as a copper

porphyrin and acts as a respiratory catalyst; but at this stage the comments of the author are rather speculative.

Having elucidated the action of the copper in promoting settlement and metamorphosis, a survey of the occurrence of copper in the water covering the natural beds was carried out. At Milford Harbor a rapid increase in copper content of the water on the ebb tide was noted, reaching a maximum concentration of about 0·6 mg./litre one hour after low water. By means of egg-box spat collectors exposed at regular periods, the variations in the intensity of setting during the tidal cycle were studied. A very close correlation between the copper content and the intensity of setting was demonstrated.

The distribution of oyster beds was studied in relation to the presence of river water, carrying with it copper in suspension, and certain, at first sight, anomalous cases have been explained. For example, in the Sea-side region in Virginia the setting of oysters is heavy although there are no rivers and very little surface drainage. However, the water has a salinity of only 27 per mille as compared with 33 per mille in the open sea. It is assumed that there is an upwelling of subterranean waters from the sea bed, and this is confirmed by the presence of copper in concentrations varying from 0·08 to 0·25 mg./litre.

A synopsis of this work was published some years ago, and experiments were initiated in Great Britain to determine whether copper played a similar role in the setting and metamorphosis of the European Oyster *(Ostrea edulis).* It has been shown that a settlement of European oysters may be obtained in tanks in which the concentration of copper is negligible when compared with the figures given for *Ostrea virginica.* Further no stimulative effect of any kind could be produced by copper salts. In view of these facts and also of the remarkable differences in the accounts of the structure and function of the "pigment spots" in these closely related species, it is earnestly hoped that further work will be undertaken on both forms which will provide a final explanation of these differences.

*H. A. C.*

**F. C. Fraser.** "Report on Cetacea stranded on the British Coasts from 1927 to 1932." British Museum (Natural History), Rep. No. 11. London, 1934.

By arrangement between the British Museum (Natural History) and the Board of Trade, Cetacea stranded on the British coasts have been reported either to the British Museum or to other national museums since 1913. Those stranded during the period 1913—26 were reported on by Sir S. Harmer in 1927. The records for the subsequent period 1927—32 have now been dealt with by Mr. Fraser.

The report gives, in the first place, a list of strandings during the period in chronological order, followed by a more detailed notice of each species and a key for identification of the British forms. In this report the external characters are noted only for previously unrecorded species or for specimens which have shown marked differences from the normal, since the common species were fully described in the earlier report. Because of the comparative rarity of whales of the family *Ziphiidae,* their skull measurements and skeletal characters have been set out at length.

During the period 1927—32, 193 strandings were reported. Seventeen species were identified, this being the same number as described in the

earlier report, but the two lists show interesting differences. The white whale, *Delphinapterus leucas,* and the false killer whale, *Pseudorca crassidens,* both from Scottish localities, are recorded for the first time since these reports commenced. Previously the claim of the false killer to be included in the British fauna rested on three sub-fossil skeletons found in the south-east of England. In October 1927, however, a school of some 150 individuals was stranded in the Dornoch Firth on the north-east coast of Scotland. A separate report on these is promised in the near future. True's beaked whale, *Mesoplodon mirus,* is reported from South Uist, this being the first Scottish record.

As in the previous report the common porpoise, *Phocaena phocaena,* was by far the most commonly stranded species, accounting for 43·0/0 of the whole series. The bottle-nosed dolphin, *Tursiops truncatus,* and Risso's dolphin, *Grampus griseus,* have been proportionately commoner than during the previous period. The common rorqual, *Balaenoptera physalus,* however, has shown a very marked decrease. During the period 1927—32 there were only two certain records, while during the period 1913—26 there were twenty-four. The author suggests that this may be due to the transfer of whaling activities to the Antarctic, with a consequent closing of northern stations and therefore less chance of wounded animals being cast ashore. It may, however, be significant of a real decrease in the total stock. It is perhaps worth noting in this connexion that whereas four blue whales, *Balaenoptera musculus,* were stranded in Scotland between 1913 and 1926, none is recorded since.

*A. C. S.*

**Newfoundland Fishery Research Commission.** Annual Report for 1933. Vol. II, No. 2. Plymouth, 1934.

This report records further progress in the important researches which are being carried on in Newfoundland[1]). Among the technical results we may note that vitamin A potency of cod liver oil increases with age of the fish.

As regards hydrology and biology, the strong flow of arctic water in 1932 was continued into the summer of 1933. This had the expected detrimental effect on the important fishery for squid (*Illex*) for use as bait, and was accompanied by abundance of *Oikopleura vanhöffeni* and scarcity of *O. dioica,* which was restricted to the southern fringe of the fishing-banks region. *Sagitta serratodentata* was also scarce and similarly distributed. These three forms are, therefore, promising indicators.

Prediction of salmon runs is barely established, but any indication is welcomed by the industry. The previous prediction was borne out.

Cod fishing, with observations of bottom temperature, confirmed the provisional scheme of "best temperatures" drawn up in the last report.

These few references may serve to show the quality of the work. There is much more, on various subjects, in the report. It is surprising and creditable that so much has been achieved in such a short time.

*M. G.*

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[1]) Previous reports were reviewed in this journal, Vol. VIII. p. 274; Vol. IX. p. 124.

**H. I. Battle.** "Digestion and Digestive Enzymes in the Herring *(Clupea harengus* L.)." Journ. Biol. Board Canada, Vol. I, No. 3. Toronto, 1935.

**L. E. Bayliss.** "Digestion in the Plaice *(Pleuronectes platessa)*." Journ. Mar. Biol. Assoc. N. S., Vol. XX, No. 1. Plymouth, 1935.

Literature dealing with the physiology of digestion in fish is scanty and it is therefore gratifying to be able to review two recent papers on this subject. Both of these papers deal with teleosts and although the particular animals studied vary widely in feeding habits, the herring a typical pelagic fish feeding on zooplankton and the plaice a typical demersal fish feeding on bottom-living invertebrates, they resemble each other closely in the anatomy of the digestive system. Each possesses a true anatomical (and physiological) stomach — absent in certain teleosts —, pyloric caeca are present, while the pancreatic tissue is diffuse and without any obvious means of conveying its secretion to the lumen of the gut.

Miss Battle makes some interesting observations on changes in planktonic Crustacea after ingestion. The reddish colour these rapidly acquire is probably due to the acid conditions in the stomach, while their advanced state of disintegration in the caecum of the stomach 5 to 7 hours after feeding indicates that this is a region of active digestion and not a mere storage organ. It is noteworthy that the chitin which forms so large a part of the food is not digested.

The remainder of her paper, and all of that of Bayliss (much fuller in this respect), is concerned with the nature of the digestive enzymes. The stomach of both fish produces a proteinase which acts in acid medium — apparently a pepsin. Bayliss failed to find evidence for the presence in any amount of the cathepsin present in the gastric mucosa of the Mammalia. As in other vertebrates the stomach is capable of secreting acid. Miss Battle records the presence of trypsin in the mucosa of the numerous pyloric caeca of the herring, but in the plaice (where the caeca are less numerous) Bayliss finds more trypsin in the liver and wall of the gall bladder (in both cases extracts of the intestinal mucosa being necessary for complete activation). He makes the interesting observation that bile itself has no proteoclastic activity, the source of the trypsin being in the pancreatic tissue which surrounds the gall bladder. In this he confirms the work of Mackay on *Fundulus*. In spite of extensive experiment he was unable to prove conclusively that this tissue is capable of secreting into the gall bladder and the route by which the secretion enters the gut still remains obscure. He also found evidences of an erepsin in the intestine.

Bayliss found a definite but weak action on starch by extracts of the intestinal mucosa, the liver, and the wall of the gallbladder but none in extracts of the stomach or in the bile. Miss Battle found strong amylolytic enzymes in extracts of the pyloric caeca and intestine. She also found some action in the gastric juice, a statement which requires confirmation. It is unfortunate that neither author used glycogen as a substrate. Both authors found lipase in the same regions that they found amylase; according to Bayliss it is especially abundant in extracts of the liver although, as he recognizes, this may be partly intracellular in action.

*C. M. Yonge.*

**J. W. Bigger.** "The Bacteriological Examination of Mussels." Journ. Hygiene. Vol. XXXIV, No. 2. Cambridge, 1934.

Some six years ago Dodgson[1]) surveyed the bacteriological problems of the mussel, pointed out fallacies and absurdities in current methods of testing shellfish and described the method used to ascertain that mussels treated at the Ministry's purificaion plant at Conway reached a high level of cleanliness. He indicated how this method — with its wide margin of safety — must be modified for the more specific purposes of the public health bacteriologist, and it is from this latter point of view that Professor Bigger once more takes up the theme.

In briefest terms: Professor Bigger analyses results obtained with 10 batches of mussels prepared for test by a standard technique and examined for excretal bacteria by inoculation of lactose bile salt broth (L. B. B.) and, for comparison, by culture in Salle's, MacConkey's and Burne-Gaffney's media. The salient point in technique is rejection of shell fluid, variable in volume and regarded as unimportant, and standardization of the volume of each mussel at 25 c. c. by addition of saline to the minced body. 10 mussels of each batch are individually examined by duplicate inoculations of 0.5, 0.1 and 0.02 c. c. of mussel mince into 30, 15, and 15 c. c. respectively of L. B. B. with Andrade indicator — volumes of broth deemed sufficient to "dilute out" acid arising by fermentation of mussel sugars. After a study of organisms recovered from L. B. B. cultures during 48 hours' incubation at 37° C., it is concluded that optimal readings are obtained at 24 hours; that acid *and gas* formation at this stage is sufficient but essential evidence of coliform growth; and that positive readings at any dilution should only be accepted where the duplicated tests agree. Finally it is suggested that, where more than 7 (of 10) mussels give positive results with 0.5 c. c. inocula, more than 3 with 0.1 c. c. inocula, or more than 1 with 0.02 c. c. inocula, the batch be considered contaminated to an undesirable degree.

This method, permitting rapid estimation of the order of coliform contamination per mussel, is claimed superior to its less quantitative predecessors and to all tests on solid media, which, failing *inter alia* to register adequately the all essential feature of gas formation, necessitate study of bacteria isolated from primary cultures — which "is impracticable".

The sacrifice of part of the evidence — the shell fluid — to the mathematics of Professor Bigger's test may be justified but that "this fluid is little more than a sample of the last water in which the mussel opened" does not entirely prove its insignificance. Time was when tests were largely based on this fluid.

This is not the first arithmetical intervention in mussel bacteriology: Klein's original test on 6 mussels was modified that uncleanliness might more readily be expressed as a percentage on 10!

The reviewer — with some slight experience — is inclined to think that Professor Bigger somewhat exaggerates the inherent difficulties of Dodgson's method, which from long practice cannot be held "impracticable". It is comforting that both workers seem to stand, pending further information, by the same simple criterion of the excretal type — a coliform achieving gaseous fermentation of L. B. B.

*P. B. W.*

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[1]) Report on Mussel Purification. Fish Invest. (II), X, 1, 1928.

**J. Hjort, J. Lie** and **J. T. Ruud.** "Pelagic Whaling in the Antarctic. IV. The Seasons 1933—1934." With a note on: "Limits of the Pack Ice in the Antarctic in the area between 40° W and 110° E," by H. E. Hansen, Hvalrådets Skr. Nr. 9. Oslo, 1934.

This paper is an analysis of the data extracted from the journals of whaling expeditions received by the Biological Laboratory of the University of Oslo, and is a continuation of the series of similar analyses made by these authors for previous seasons. The analyses for the season 1933—1934 are made more comprehensive by the addition of data from the journals of several expeditions of nationalities other than Norwegian.

As in previous papers in this series, the region where pelagic whaling is carried on has been divided into a number of zones, based on lines of latitude and longitude. Tables are appended, and summarized in the text, giving particulars of the catch obtained by the whole whaling fleet month by month in each zone. The monthly movements of the whaling fleet throughout the season are shown on a series of charts.

The season 1933—4 was in many respects similar to the season 1932—3. As in previous seasons 50 % of the catch was obtained in a zone between the longitude of Bouvet Island and Kerguelen. The main body of the fleet moved eastwards and southwards from the outer zone of the pack ice between these longitudes to concentrate off the coast of Enderby Land between 50° and 65° E. At the beginning of January the fleet began to move westwards along the coast and continued to do so until the end of the season. A portion of the whaling fleet operated in the Weddell Sea sector south of the South Sandwich Islands, moving east again towards Bouvet in March. These movements are similar to those which took place in 1932—3 and, as in other seasons, the maximum catch of blue whales was obtained between November and December, and of fin whales in January and February. The Weddell Sea sector from 0° to 60° W., which has been longest exploited, still exhibits the highest proportion of immature whales. In *Hvalrådets Skrifter* No. 3 the authors were inclined to attribute this less to any exhaustion of the stock in this area than to other possible causes. They suggested that young whales may have a migration route of their own which lies through this region.

The season 1933—4, however, shows two important differences from other seasons. Firstly, the largest number of whales, and the largest oil output per "catcher's day's work" was obtained not in the Bouvet-Kerguelen sector, where the main catch was taken, but in the older grounds in the Weddell Sea sector. This area was operated by three floating factories which were among the best equipped of the fleet and the authors conclude from this that conditions were as good last season for a limited number of well-equipped expeditions on the old grounds as on the newer grounds farther east. The second difference from previous seasons was the high proportion of whales other than blue whales — mostly fin whales — in the catch. This the authors attribute to the fact that the whalers deliberately sought fin whales last season in order to spare the stock of blue whales, and to the fact that modern factory ships are better able to work in the open sea, where the fin whales are, than the older ships, which required the protection of the pack ice. The figures are not taken to indicate any diminution in the stock of blue whales.

The authors discuss the influence of whaling activities on the stock of whales and stress the importance of the catch per "catcher's day's work" as a means of estimating changes in the stock in accordance with the intensity

of operations. So long as there is no change in the catch per "catcher's day's work" the authors assume that sufficient replacement of the stock is taking place. They point to an increase during 1933—4 in the catch per "catcher's day's work" but explain that this may be due to the increased catching efficiency of the fleet under the new production agreement, which has eliminated the less efficient companies. It is pointed out that the new system of remunerating gunners according to the number of "calculated blue whales" delivered at the factory ship may have a detrimental effect on the stock by encouraging the killing of large female whales, and thus increasing the proportion of pregnant whales taken.

A section is included in the paper in which are summarized the numbers of whales observed by the "Norvegia" Expedition 1930—31 during that vessel's circumnavigation of the Antarctic, together with the observations of the whale factory "Solglimt" and the tanker "Thorshavn", which steamed eastwards on parallel courses during the season 1933—4 across the South Pacific sector of the Antarctic. In brief, the "Norvegia" observations show that blue and fin whales are found in the South Pacific at least at certain times of the year, but the observations are insufficient to show whether there are ever enough whales to render whaling profitable. In the first half of February the "Solglimt" and "Thorshavn" found almost none in this sector.

*F. D. Ommanney.*

**J. F. G. Wheeler.** "On the Stock of Whales at South Georgia." Discovery Rep. Vol. IX, pp. 351—372. Cambridge, 1934.

In Volume VI of this Journal I had the pleasure of reviewing two previous papers in the *Discovery Reports* concerning whales. In these papers the method of age determination of female whales by means of the number of corpora lutea in the ovaries is given in detail, showing that every two-year group commencing at sexual maturity, consisting of ovulating, pregnant, lactating and resting females, corresponds to certain numbers of corpora lutea.

Physical maturity of the female fin whale was found to correspond to 15 corpora lutea in the ovary, probably nine years from birth.

Over seven seasons from 1924—25 to 1930—31 age-determinations of female fin whales based on this method have been made by the Discovery staff at the "Pesca" whaling station in South Georgia. Dr. Wheeler gives us in the present paper a discussion of the age composition of the catch of fin whales based on these age-determination data.

From the age composition found the rate of reduction is calculated. If we accept the method of age-determination, the validity of the calculated rate still depends on two postulates, (1) the annual recurrence of the same stock of fin whales to the South Georgia waters, and (2) the representativeness of the samples (catches) considered.

It seems impossible to obtain proof indirectly of the identity of the whales visiting the area in successive seasons, though certain facts in the history of whaling as well as the composition of the catch in different areas support this conception.

The whales at South Georgia appear in "batches" at different stages of maturity. "Over five complete seasons the majority of physically mature females appeared in December, the majority of sexually mature not physically mature females in January and the peak of the influx of immatures was in February."

In five out of seven seasons almost the entire catch of the "Pesca" company was examined, and there is no reason to believe that the catch examined should not be representative of the total South Georgia catch. The catches from the five complete seasons are therefore considered as a unit, although the possibility of errors arising by this treatment are realized.

The total number of mature females considered is 431, and this material is arranged in "two-year" groups starting at sexual maturity. Between the first six groups the calculated rate of reduction has an average value of 26 per cent. Beyond the sixth group the rate of reduction is greater, suggesting that other sources of loss affect the older whales, perhaps another route of migration or avoidance of the locality.

The two-year groups can be divided into one-year groups, the lactating and resting females being one year older than the pregnant or ovulating whales. This analysis reveals a shortage of lactating and resting whales, but as the proportion between these and the pregnant or ovulating whales in every two-year group is nearly constant, this can only mean that a certain proportion of whales in the post-pregnant condition do not appear on the South Georgia grounds during the season. Therefore the catch from the five complete seasons is considered as representative, and the calculated rate of reduction is considered as "the rate at which the stock has been reduced, at South Georgia or elsewhere, by hunting, by natural death, disease or any other cause of elimination."

The material allows certain interesting calculations, all of which have been made by Mr. T. Edser.

In the two-year groups: 3—4, 5—6, 7—8, 9—10, 11—12 and 13—14 years from birth, the number of females considered are: 130, 95, 72, 53, 37, and 28, and by means of these first six terms the initial stock of females in the 3—4 group is estimated at 497. Further the theoretical stock in each two-year group, the surviving stock and the stock of older females absent from South Georgia is calculated.

Taking for granted that each mature female gives birth normally to one calf in the two-year period, the reproduction can be estimated at 232 females in two years. 269 immature females, however, is the estimated number necessary to keep the stock level.

So far it may be concluded that considerable damage is being done. If, however, the older whales absent from South Georgia are also adding calves to the stock of immatures, the reproduction will be 269 females in two years, just balancing the losses.

The author stresses the indicative rather than the exact nature of these results.

So far the immature females in the catch, amounting to 32 per cent., have not been considered. According to the theory advanced by Mackintosh and Wheeler in the first *Discovery Report*, the fin whales attain maturity in their second year. As the sucklings are protected by law and only taken by accident, the majority of the immatures should belong to the age-group 1—2 years old.

The author introduces the term "scar-ages". On the flanks and tail of nearly all whales examined in South Georgia series of scars in the skin are observed. Fresh series of these scars, which according to previous reports are formed in the tropics, can often be distinguished from the older series by their whiteness.

It is possible, if the number of scar-series is small, to count how many seasons the young whale has migrated south and north.

This indication of age shows that by no means all females attain maturity

in their second year. The immatures in the catch, exclusive of the sucklings, may really be composed of two year-classes.

This fact will naturally also affect the subsequent age-groups, determined by their number of corpora lutea. The ages from sexual maturity are of course the same, but a pregnant female with 1 to 4 corpora lutea may be either 2 og 3 years old, and so on for the following groups. The rate of reduction, however, is unaffected; in starting from sexual maturity the age determinations are correct.

The catch from the season 1929/30 has been analysed with regard to all known facts, scar-ages as well as age determinations by corpora lutea. The finding is that the greatest damage to the stock is spread over the period between the second and seventh years of life.

The author realizes that many errors are introduced through the treatment of the material, many of which are impossible to estimate.

His conclusions must therefore be regarded as indicative of the state of affairs.

This comprehensive paper has bearing on many problems of vital interest to the whaling industry: I have only indicated the results I consider of most general interest. I find it very valuable that it has been possible to introduce age analysis of the stock in the discussion, but I fully agree with the author in his statement that "The crux of the problem is the identity of the whales visiting the area in successive seasons."

*Johan T. Ruud.*

# Current Bibliography.

Prepared by the Editor with the assistance of Miss Thursby-Pelham.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. Allen's Selected Bibliography published in Vol. I, Nos. 1 and 2 of the Journal, and since reprinted (Price, 1 Kr.).

Subscribers and those on the distribution list will receive regularly upon application to the Administrative Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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